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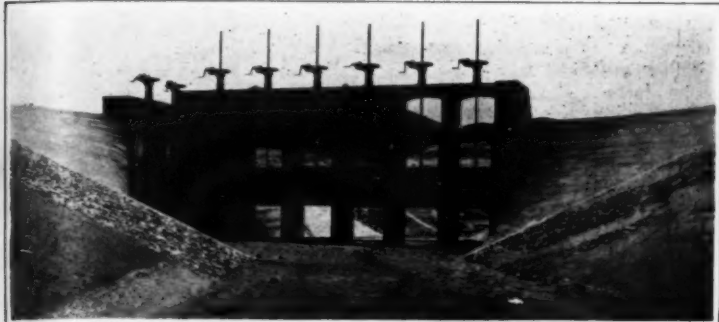
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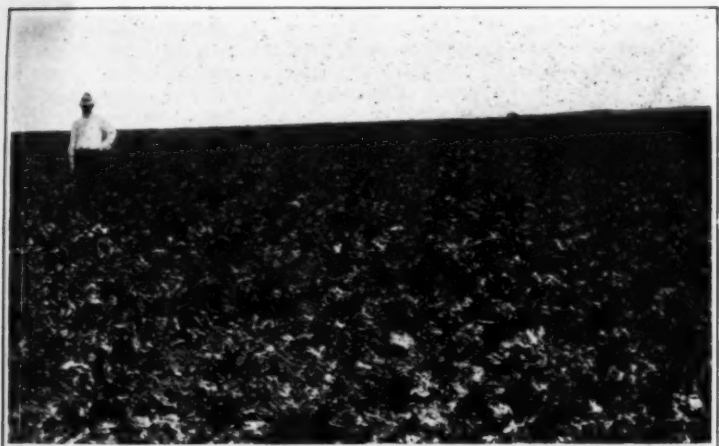
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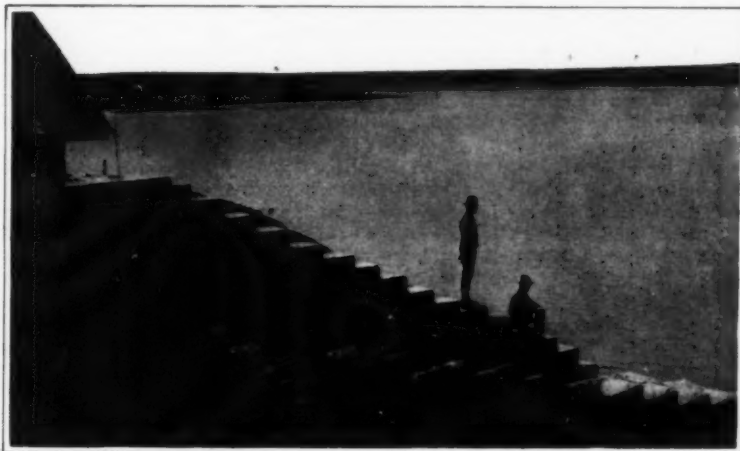
Truckee-Carson Project, Nevada. Pyramid Take-out on the Main Truckee Canal.



Truckee-Carson Project, Nevada. The Congressional Party Investigating the Headworks on the Carson River.



Sugar Beets on a Forty-acre Farm. In 1910 the Owner Received \$3,170 for Beets. Grown on Thirty-one Acres.



The Carlsbad Project, New Mexico. This is the Lake Avalon Reservoir.



Headworks of the Sunnyside Canal and Yakima Dam, Yakima Project, Washington.



Roosevelt Dam as Completed in April, 1910. View Across the Gorge.

SOME EXAMPLES OF THE ACTIVITY OF THE UNITED STATES RECLAMATION SERVICE. [SEE PAGE 102.]

# Practical Aspects of Printing Telegraphy—III\*

An Inventor on the Difficulties to be Encountered and the Way to Overcome Them

By Donald Murray, M.A.

Continued from Supplement No. 1857, page 96

It is the usual practice of telegraph administrations to keep a record of each message sent out for delivery. In some cases a note is made of the preamble and address. In other cases a copy of the whole message is retained. The custom of the British Post Office is to make a carbon copy of each message that is to be sent out for delivery, the original, or "top copy," being kept by the Post Office for reference and the carbon copy being issued to the public. When messages are written out by hand from the Morse sounder or from Wheatstone tape the making of a carbon copy of each message is a simple matter. The great bulk of British telegrams are dealt with in this way, but the gradual introduction of typewriters and printing telegraphs is rendering a change necessary, because it is not practicable to make carbon copies of messages when a typewriter or printing telegraph is employed. The reasons are as follows: In all countries there are two classes of commercial messages. In Great Britain these are known as S and X messages. The S messages are those for delivery to the addressee. X messages are those passing through town B from town A to town C. They are messages written down for retransmission over another circuit. These are not issued to the public and do not need to be copied. As much as half the traffic in large towns may consist of X messages.

In America wet press copies are taken of messages that go out to the public, and this method was proposed in London when the Murray automatic system was first started, in 1902, between London and Edinburgh, but various objections were raised to it. The Murray automatic printer could prepare from 12 to 16 good carbon copies of messages, but the carbon copy method could not be used because it was not possible to tell whether an S or an X message was coming over the wire at a high speed, and there was not time to slip in carbon paper for one message and not for another. Either all the messages would have to be carbon copied from a continuous roll or none at all. Arranging for carbon copies from a continuous roll was found to be very troublesome, expensive and impracticable. A variety of proposals were made. One was to have the platen of the typewriter itself covered with a jacket of typewriter ribbon material and a roll of tissue paper feeding in. The message would then print on the ordinary forms and give a tissue copy inked from the back by the ribbon cover of the platen. Investigation showed that this idea was not a good one. Another proposal was to blacken with the carbon composition the backs of the message forms, and they would then themselves supply a fine carbon copy on paper behind them. What the public would have thought of telegraph messages smudged all over the back with dirty carbon pigment is easily imagined. That idea was abandoned. The whole of the possibilities were gone through most carefully, and finally it was decided that the best way was to arrange for a "check-table" girl to make a written note of the preamble and address of all S messages that came over the Murray circuit. As this work only occupied half the time of this operator, it was reckoned as the time of half an operator. Laboriously copying by hand at 15 words a minute with risk of error messages printed by a machine automatically at 100 or more words a minute does not seem very sensible, but it was the best thing that could be done under the circumstances, and it has been adhered to until quite recently. On the Hughes circuits also a check girl notes for record the preamble and address of Hughes messages. One reason for this arrangement is a good illustration of the complexity of telegraph work. The girl at the check-table was advantageously employed for this work because she was a "circulation expert," and, therefore, only copied S messages, her experience enabling her to tell at once which were S and which were X messages. For instance, "Silvergray, London," has to be delivered at Silvertown. It is therefore an X message and need not be copied in London. For part of Oxford Street, London, messages are delivered by tube, and part needs a telegraphic retransmission. Operators do not know the tube deliveries, but the circulation experts do. Of course, the whole of this trouble would disappear if the messages were press copied in the delivery office, where there are no X messages. Another proposal was that as the Murray automatic printer printed the messages from a perforated tape, any S messages should be printed twice

by pulling back the tape and reprinting from it. This was tried and found to waste too much time. The only practicable method, therefore, is a wet-press copying as done in America. There, a roller copier is used driven by a small motor. This was tried in London, but various difficulties were met with. Dampening the sheets of tissue and handling the damp tissues proved anything but successful in the rush of telegraphic work. At that time the elaborate roller press copiers now in commercial use had not been developed. A photographic roller enameller was tried and with a few alterations gave good results. Bunches of tissue paper were soaked in water, and then run through the rolls to press out superfluous water, but the sheets were found to be so difficult to separate that much time was lost and the arrangement was impracticable. Also the damp tissue had a tendency to stick and wrap itself round the rollers of the copier. An American telegraph operator, who happened to be in London at the time, showed how it was done in America. Blowing sharply with the mouth on the edge of the mass of damp tissues separated them at the corners instantly, and enabled them to be pulled apart quickly. He also showed that 8 or 10 telegrams could be copied simultaneously by piling them up interleaved with the damp tissue sheets, folding the bundle in half, and running it through the rollers. The folding prevents the tissues sticking to the rollers and halves the time required to run through. In America, where the use of typewriters for telegraphic work is universal, the wet-press copying of S messages is done in the delivery office. This is simple and convenient; but when a new printing telegraph is being introduced in a country where messages are received by Morse sounder and written out with pencil and carbon paper, it is obvious that a press copying outfit cannot be installed in the delivery office for the sake of a few hundred telegrams a day, out of many thousands. That would waste much time and labor. Copying must be done near the receiving mechanism of the circuit until typewriting or printing telegraphy comes into fairly general use in the large towns. Also the copy must go with the message to the delivery office. It could not, therefore, be taken on a press copier using a continuous roll of tissue paper. The damp-press copies would also have had to go with the messages rolled up in bundles, through the pneumatic tubes, and that would have been liable to cause trouble. To avoid this difficulty it was proposed to use alcohol instead of water to damp the tissue paper, paper so damped giving an excellent copy from methyl-violet type-writing ink, and the alcohol dries quickly. The danger of fire, however, prohibited this idea. Under all the circumstances, copying the preamble and address by hand was the only thing possible. Recently the development of the modern press copier for commercial office use has brought the question up again. Rolls of tissue paper, already damped with glycerine and water are obtainable, and these retain their slight dampness for a considerable time as the glycerine is hygroscopic. But these big press copying machines are useless in cases where the copying has to be done at the circuit. The cost of the copier for a single circuit, the space occupied, the labor, and the delay in cutting up tissue into separate messages to accompany the originals make it useless. In the delivery department one of these modern press copiers is very suitable, as all messages there are S messages and have to be copied, and one copier can handle the messages from many circuits. In America, before the introduction of the typewriter for telegraph work, the pencil and carbon paper method still used in Great Britain was employed. With the Morse key and sounder and hand-written messages, this plan is ideal, because the operator has ample time to slip in a sheet of carbon paper when necessary. With the introduction of the typewriter there was no longer time to slip in carbon paper for some messages and not for others, and there was too much waste in copying all messages in this way when only about half needed copying. The Americans being less embarrassed by imaginary obstacles, wet-press copying in the delivery office was established as a matter of course.

In England another serious obstacle to the introduction of a rational method of copying telegrams was as follows: Some progressive officials in London, greatly daring, urged that the "top copy" should be done away with. They said, "Abolish it. We have the message as handed in by the sender, and if the

recipient has any complaint to make let him produce the received message. We can then compare the two copies and see what is wrong, and refund the 6d for the telegram if the Department is to blame." The abolitionists, however, have not been able to overcome the scruples of the Auditor-General of the Post Office, who for financial reasons has an elaborate system of checking the telegrams and the number of words paid for. The subject is really excessively complicated, and it has been dealt with fully here because it is a good illustration of the difficulties that the printing telegraph inventor has to face, subtle, invisible difficulties that even highly trained technical telegraph men do not themselves realize till they come up against them. Wet-press copying in the delivery office is rapid and free from error, and it is the only practical method of copying messages when printing telegraphs are used and when only some (roughly about half) have to be copied; and in time it will be adopted in all cases where a telegraph administration finds it necessary to preserve a copy of messages sent out.

## S AND X MESSAGE FORMS.

The distinction between S and X messages has already been explained. X messages are well named because they cross through city B from city A to city C. An X message in city B becomes an S message in city C, where it is to be delivered. Not only do these two different kinds of messages give trouble in connection with making copies, but they also give rise to a further obstacle so far as page-printing telegraphs are concerned. Practically all administrations have two kinds of telegraph forms or blanks for the two kinds of messages. In the case of printing telegraphs like the Hughes and Baudot, which print their messages on a tape, the S & X message forms present no difficulty as the tape can be pasted on to either as may be required, and in any position. For instance, in France the piece of tape containing the address is pasted on the back of the message form, and in Germany in the middle at the top. Also in the case of the Morse key and sounder, it is an easy matter for the operator to select an S or X form as may be required. In the case of a page-printing telegraph, however, it is impossible to know whether an S or an X message is coming over the line until the printing of the message starts, and then it is too late to change the form, and it would cause too much waste of labor if the sending station had to announce beforehand whether an S or an X message was being sent. The only way out of the difficulty in the case of a page-printing telegraph is to have one kind of form for both S and X messages. Administrations are reluctant to make changes like this in their established forms. In Great Britain also there are two different forms for inland and foreign telegrams, C forms in the case of foreign and B forms in the case of inland messages. The same difficulty arises here also, and one form has to be used for both. Those who are sufficiently interested in the matter will find at the left-hand top corner of page-printed telegrams that they may receive in Great Britain the letters C or B, meaning that the form is to be used for either inland or foreign telegrams. When the Murray automatic page-printing telegraph was brought from New York to London in 1901, the British Post Office had to prepare a special telegraph form for it combining the S and X and the C and B forms, and to make it distinctive the heading was printed in green ink. A special form had to be adopted for it in Germany and other countries also for the same reason. Fortunately the advantages of page-printing are more than sufficient to counterbalance this initial inconvenience.

## NUMBERING MESSAGES.

There are other difficulties that are confined to one administration. For instance, in America and on the Continent or Europe it is customary to number each message consecutively. The receiving operator can then tick off the messages on the number sheet as he receives them. A missing message is noticed at once. The British post office used to employ numbers for messages, but eventually abolished numbering as it was found not to be absolutely necessary with the Morse key and sounder. Numbering was also abolished in the case of the Wheatstone. Instead, the "name to" of messages was written on slips kept for the purpose. This seemed unnecessary, and the messages were then run in batches of no definite number, and the "received" signal to the distant office was "R D batch" (received batch) at the conclusion. This

\*Paper read before the Institute of Electrical Engineers.

rather loose practice has now been modified, and a record is again kept of each name and acknowledgments are sent in bulk. This means waste of time, but the numbering wastes line time, which is worse, especially when the line is in bad condition and there is no speed margin. Numbering messages involves a waste of about 21½ per cent in line-time and labor, and as every signal costs money in telegraphy the tendency is to omit all unnecessary signals. Whether consecutive numbers on telegrams are necessary appears to be an open question. Certainly numbering is a safeguard against messages being lost—an accident that happens occasionally in all telegraph offices. Hence when the Murray automatic system was introduced into the British telegraph service it was considered desirable by the officials to resume the numbering of messages on the Murray circuit. This is a small matter, but it involved a certain amount of change of routine, and in a big department a change of routine is a matter of difficulty. It certainly is to the credit of the British and other telegraph administrations that they have shown such willingness to make these and other considerable changes to accommodate the Murray and other printing telegraphs. The experience of the writer is that the real conservatives are not the official heads but the operators, who often show extraordinary reluctance to accept change of routine. In fact, that is one of the minor obstacles to the introduction of printing telegraphs. Of necessity, in the case of a new machine of this kind, improvements suggest themselves after months of practical experience; but by that time the operators have become accustomed to working the machine, and over and over again the writer has been told that improvements he had made were changes for the worse and that "the old machine was much better." It takes weeks before an improvement gives satisfaction to all.

## COUNTING WORDS IN TELEGRAMS.

Following upon the numbering of telegrams comes the numbering of words in telegrams. This is a serious matter, causing much waste of time and labor. It is a burden from which the telephone is free because the telephone charges by time and not by the number of words. Charging by the number of words is a very defective system, but it is difficult to say what better arrangement could be adopted. As long as word-counting remains in force it will be one of the hindrances to any considerable saving of labor by printing telegraphy. The number of words in the message is sent in the preamble, and it is the duty of the receiving operator to count the number of words in the received message to see that it agrees with the number in the preamble. If it does not it is a case of "wrong number." Suppose the preamble gives 14 words and the receiving operator can only count 13. He telegraphs back the recognized British inquiry signal "RQ" and adds "13 w." The operator at the sending station then repeats the first letter of each word in the message until the missing or superfluous word is found. This is a specially easy and quick process with the Morse key and sounder, but it is not so quick with any printing telegraph because talking back and forward is not so quick as with the Morse key. Counting the number of words in a message is a valuable check on the accuracy of transmission. Also the administration is bound to transmit the number of words that have been paid for; but the waste of time and labor on counting words is very considerable. In telegraphy "wrong number" is one of the most frequent "RQs," and, in fact, when the apparatus and line are working well there is hardly any other. Often 60 or more messages will go through without a single correction or inquiry except on account of "wrong number." Probably in more than half of these cases the message has been correctly transmitted, but the number of words has been wrongly counted at the sending or at the receiving station, and an agreement has to be reached on this point before the message can be passed on. It seems an easy matter to count the number of words in a telegram, but in reality it is quite difficult and requires experience, and it makes the task of the receiving operator distinctly responsible. Not only may the sending and receiving operator count the number of words wrongly, but they may differ in their methods of counting. There are a very large number of words that may be described as more or less Siamese twins. You can call them one or two as you please. There are many official regulations on the subject. "Fishmerchant" is sometimes counted as one word and sometimes as two. The receiving operator has to ask sometimes how it has been counted. There are two Ashursts in England, and to distinguish the second one it is known as "Ashurst Hants," and this counts as one word equally with "Ashurst." There are hundreds of similar cases all over the world. Also there are many new Siamese twin words born almost every day, and lists of words to be counted as one or as two are issued from time to time. "Motor split" is counted as one word. The German word "Sago-

mehl" (sagomeal) is reckoned as one word in Germany but as two words in England. "OHMS," the contraction for "On His Majesty's Service," is counted as four words if in capital letters; but when printed in small letters, thus "ohms," it is the unit of electrical resistance and is one word. Printing telegraphs, however, usually employ capital letters and figures only. The words would then go in capital letters OHMS. On the other hand, in Germany small letters and figures only are used in telegrams, and the contraction for "On His Majesty's Service" would then appear as "ohms." This is not the only puzzle in counting words. According to the regulations of the British post office:

"Already" is one word,  
"Alright" is two words.

"Errands" is one word,  
"Erands" (contraction for East Rands) is two words.

"Blackbird" is one word,  
"Whitebird" is two words.

"Threehalfpence" is one word,  
"Three hundred" is two words.

"Motorbus" is one word,  
"Motordriver" is two words.

"Motorboat" is one word,  
"Motorlaunch" is two words.

"STCATERINESONTARIO" is one word,  
"PRESSASSN" is two words.

It is only fair to say that similar anomalies are to be found in the case of all telegraph administrations. They certainly do not smooth the path of the printing telegraph inventor.

## ERRORS IN TELEGRAMS.

Apart from these difficulties, the most serious trouble a printing telegraph system has to face is errors in telegrams. The sender of a telegram may make a mistake, or his handwriting may be bad. The operator who transmits a telegram may make a mistake. The sending apparatus may cause an error. Disturbances on the telegraph line, stray currents, inductive interference, men repairing the line, wind and weather, may all introduce errors into a telegram. The receiving apparatus may cause a mistake. The receiving operator may not notice the mistake and the message may go on for retransmission to another town. The retransmitting operator may make a mistake, and the chain of points where errors may occur are repeated with each retransmission. Considering the possibilities, it is remarkable how few errors actually occur in telegrams.

In an ordinary message nine errors out of ten in words are sufficiently obvious to induce the receiving operator to ask the transmitting station for confirmation or correction. With figures, on the other hand, the context is no guide, and a mistake in figures is not detectable by inspection. In cipher messages containing groups of figures, the code maker's practice of adding up each group of figures and telegraphing the total as a check can be followed. This plan has the advantage that the check signal is brief, but it does not guard against horizontal transposition of the figures unless the adding is done vertically. Assume, for instance, that the message contains the figures 23 371 27 17 6. Adding up these figures horizontally gives 39, which again gives 12, which finally gives 3. Obviously any transposition of these figures will make no difference in the total, and the error of transposition is very common. Addition guards against a wrong figure, but it does not guard against two wrong figures cancelling each other's error so as to give a correct total—7 and 3, for instance, instead of 6 and 4. The chances against this are large, but it is possible. Also it does not guard against a wrong figure and a wrong addition neutralizing the wrong figure. The chance of this, however, is very small. Adding the figures vertically we get—

$$23 + 371 + 27 + 17 + 6 = 444.$$

Any horizontal transposition will show at once in this total. Further additions, however, will give the same total 3 as before. That is to say, three 4's are 12, and 1 and 2 are 3. The figures can be transposed in any possible way vertically or horizontally, and the total will always be three. As a check for a few figures addition is of little value, but for long cipher messages it is a useful though not infallible check.

Repeating the figures is a check always used in the British telegraph service with the Morse key and sounder, but this also is not a perfect check, because the human mind is so liable to fall into habits; and if an operator sends a wrong figure he is very liable to repeat his mistake when repeating the figures at the end of the message. Also if an operator receives wrongly the error is liable to go unnoticed in spite of repetition, especially 3 for 4 or 4 for 3 in Morse,

these Morse figure signals, when repeated, differing only by a single dot, thus:

3 - - - - -  
4 - - - - -

With keyboard sending there is the additional risk that some defect may develop in the instrument, causing a particular figure to miss occasionally, and repetition of the figure will be liable to repeat the error. The human failing is thus paralleled by the machine. This rarely happens with any of the good modern keyboard instruments for sending, but the possibility is there. A figure check that is practically perfect was suggested by Mr. W. A. Hatfield, a member of the British Post Office engineering staff. It consists in the repetition of figures that occur in the address and text of the message as letters at the end of the message—thus:  $a=1, b=2, c=3$ , etc. This is taken from the British telegraph clock code time, in which  $a=1$  o'clock,  $b=2$  o'clock, and so on. This code is well known to the British telegraph operators. Hence its use as a figure check in the British telegraph service is very easy. In any case it is not difficult to learn. It will be noticed that different keys are employed to repeat. This guards against an error due to a defect in one figure key being repeated, and it also prevents the operator repeating an error through habit. The arrangement was adopted with the Murray automatic system, the figures being repeated as letters in a separate line at the bottom of the message. This reduces the output of messages, probably by about 10 per cent, but it is an admirable safeguard, particularly in the early stages of a printing telegraph system before all the mechanical troubles have been overcome. When cipher messages consisting of groups of figures are being transmitted, the repetition of figures as letters is cumbersome, and transmission at the end of the message of the sum of each group of figures would probably be the best check. Up to the present the code makers are the only people who have availed themselves of this plan.

The great majority of the small errors made on keyboards are transpositions of letters, such as "aer" for "are." Some of these transpositions are rather puzzling. For instance, "Sne dat once" needs a moment's thought to see that it should read "Send at once." This was an actual mistake, and it is interesting because it is a case of double transposition,  $e$  and  $a$  being transposed and then the space and  $d$ . Double transpositions are not uncommon. When the mind stumbles it often stumbles again in trying to recover itself. Other errors of this kind that have actually occurred are "Engaldn" for "England" and "Motnsh" for "Months." Transposing is a common error also in writing. It is not confined to type-writing.

It is necessary for the operator to have considerable experience of telegraph messages to perceive mistakes. For instance, "fmcht" is clearly a mistake to any one not acquainted with the subject, but it happens to be the customary contraction for "fishmerchant." A good example of the care and discretion necessary in checking received telegrams is as follows. One day a telegram came through something like this: "Buy 100 tintos for ries." Apparently the sending operator had fallen into the usual error of transposing. He had mixed the  $e$  and the  $s$ , and the telegram should have read, "Buy 100 tintos for rise." Fortunately the receiving operator asked the sending operator whether "ries" was right, and it was. That telegram came through without error, but it involved delay and inquiry. There are many such telegrams, and they materially reduce the number of messages that an operator can handle per hour, and thereby increase the cost of telegraphy to the general public. On the telephone there would have been no doubt about that message and no delay. If telegraphy was straight-ahead routine work in a steady, continuous stream all day, without any need for headwork on the part of the operator, telegrams would only cost a quarter of what they do now, and the printing telegraph inventor would have an easy task.

Another fertile source of errors in telegrams is careless and indistinct handwriting on the part of the public. For example, cruisers certainly are bruisers, and the British Admiralty would like to be Almighty, but a certain editor must have been rather surprised when he got a telegram announcing that "The Almighty has ordered three new bruisers." In this case the operator was also to blame for allowing such nonsense to pass, but in the following instance the operator was not at fault, as the mistake probably arose from the use of the old-fashioned  $s$ , written like  $f$ . A man in London told his wife in New York to come over to London by a certain steamer, and then at the last moment decided to go to New York himself and accordingly telegraphed to his wife, "Don't sail." The telegram as it reached his wife read, "Don't fall." She took it as instructions to sail without fail, and she did so, only to find on arriving in London that

her husband had also sailed without fail to New York. Another class of errors is that due to defects in the apparatus. Printing telegraphs, especially new ones, drop letters occasionally. In one instance in London the letter *z* was missed from the address "Zurich," so that the message read "Urich." By some unhappy chance there is a town named Urich in Montana, in the United States, and the telegram accordingly went to America instead of Switzerland. The mistake was not discovered till the message had come back from Urich in America, undelivered, two days afterwards.

On the other hand, it is the general experience that good printing telegraphs reduce the number of errors in telegrams compared with the Morse key and sounder. Printing telegraphs eliminate a whole class of errors due to misreading of Morse signals. Also signals sent by a machine are of necessity more precise and accurate than hand signals can possibly be. It is for this reason, among others, that automatic transmission is now practically universal on ocean cables. It is an undoubted fact of experience, both in Great Britain, the United States, and other countries, that printing telegraphs, when in satisfactory working condition, reduce the percentage of errors very materially compared with the Morse key and sounder.

As an example of a Morse error the following may serve. A message was handed in at an office in Ire-

land: "Deliver Ten Pigs." This was mutilated in transmission into "Blister ten pigs." The Morse signals are identical, but the spacing differs, thus:

D	E	L	I	V	E	R
B	L	I	S	T	E	R

Complaint was made about the pork and mustard error, damages claimed, and sixpence, the cost of the telegram, was refunded by the Post Office.

Not only is long experience necessary for the quick detection of errors, but familiarity is also desirable with the traffic on particular circuits. Registered addresses are often peculiar, and slight mistakes on the part of the sending operator might cause a wrong delivery of a message. Experience on a circuit will detect such errors at once, as registered addresses occur frequently on particular circuits and become familiar to the receiving operator. Also the usual trade contractions must be known—for instance, "fmcht" for "fishmerchant." "Ystradyfodwg" is a real name, though it does not look right to the uninitiated. "Gwrwch," another Welsh town, is also correct, although its looks are against it. "Gablonzanderneisse" is obviously correct, and "Steatherinesontario" and "Stmalolleetvillaine" are quite right and count as one

word each. Printing telegraphs occasionally become what the French called "derailed" for a few seconds, and a meaningless jumble of letters is printed. Fortunately this kind of error is recognizable after a little experience, as the "derailment" gives characteristic results with each kind of printing telegraph. Hence the only evil consequence is a little delay. Code and cipher messages are also a sore trial for the telegraph operator, but such messages come through, on the whole, more accurately on a good printing telegraph than with the Morse key and sounder.

The method of getting corrections and making inquiries is ingenious and brief. RQ is the British signal for an inquiry, and the following contractions are used:

A A = All after.  
W A = Word after.  
L W = Last word.  
M M = Office of origin.

"What is the word after urgent in message No. 125" would be sent "125 W A urgent." If the last word is in doubt, the inquiry would be "125 L W." The sending operator also anticipates inquiry in regard to curious words by repeating them at the end of the message. This saves time.

(To be continued.)

## Aeroplane Stability

By Arthur Holly Compton, Physics Laboratory, University of Wooster

WHEN we remember that during the past year men have flown from almost dawn until dark, covering hundreds of miles without touching the ground, we realize that support in the air is no longer a troublesome problem; but when we look at the long list of

fatalities that have occurred, we see great room for improvement before men will be able to use the air as safe highway. In considering these accidents, we find that they arise mostly from three causes: 1, Faulty construction; 2, undue recklessness, and 3, poor

equilibrium. The first of these does not concern us at present, for it requires only a few years' experience before this fault will be overcome; and if an aviator wishes to deliberately turn his machine down at an angle of 45 degrees until it strikes the ground, we have no means of preventing him; but is it not possible to so construct the machine that with reasonable care the large proportion of accidents due to faulty balance may be prevented? It will be the purpose of this paper to determine the conditions on which the stability of aeroplanes depend, and to suggest some means whereby such stability may be automatically maintained under all possible conditions.

In order to understand the difficulty of this problem, we must first obtain some idea of the turbulence of the air. Even in the calmest weather the atmosphere is greatly disturbed. The sun shining on each dry field and on the roof of every house forms enormous bubbles of hot air, which rise up in great inverted whirlpools through the colder strata above. The winds are far from being regular currents of air. Like breakers on a seacoast, the wind strikes each tree and house and hill, glancing up hundreds of feet in whirling columns. One obtains an idea of the disturbed state of the atmosphere when one sees an aeroplane knocked up or down by a sudden gust of wind, 10, 20 or even 30 feet in a few seconds.

The problem of stability resolves itself into keeping the center of air pressure and the center of gravity in the same vertical line, while sailing through these rolling masses. The first experimenters tried to do this by shifting their weight while flying, but found it a difficult and at times impossible task. Otto Lillenthal, after making over a thousand successful glides in this manner, was finally overturned by the wind and killed. In 1901, however, the Wright brothers constructed a flyer on a new principle. Instead of shifting their weight to keep the machine balanced, they put a horizontal rudder in front, by which they could keep themselves from turning over frontward or backward, and twisted the tips of their wings to obtain lateral stability. With a little practice on this machine they could work it semi-automatically, like a bicycle.

The principle on which Wright's aeroplane works, that of operating stabilizing planes to counteract every variation of the position of the center of air pressure due to changes in the direction and velocity of the wind, is now used on every successful type of aeroplane. With the elevators and stabilizing planes made of moderate size and placed at the ordinary distance from the center of gravity, the balance of the aeroplane may be kept under perfect control in the most irregular winds, if the auxiliary surfaces are always set in the proper position. But when we remember that at times the birds themselves are knocked over by gusts of wind, and sometimes even fall to the ground before they can regain their equilibrium, is it surprising that sometimes the most experienced aviators should not be quick enough to set the rudders to meet every gust?

What, then, will happen if the aviator is attacked by "air-sickness" or becomes unconscious on account of too rapid rising or falling through the air? In order to avoid accidents from these causes it is necessary so to construct the aeroplane that it will be securely kept in the proper position, either by in-

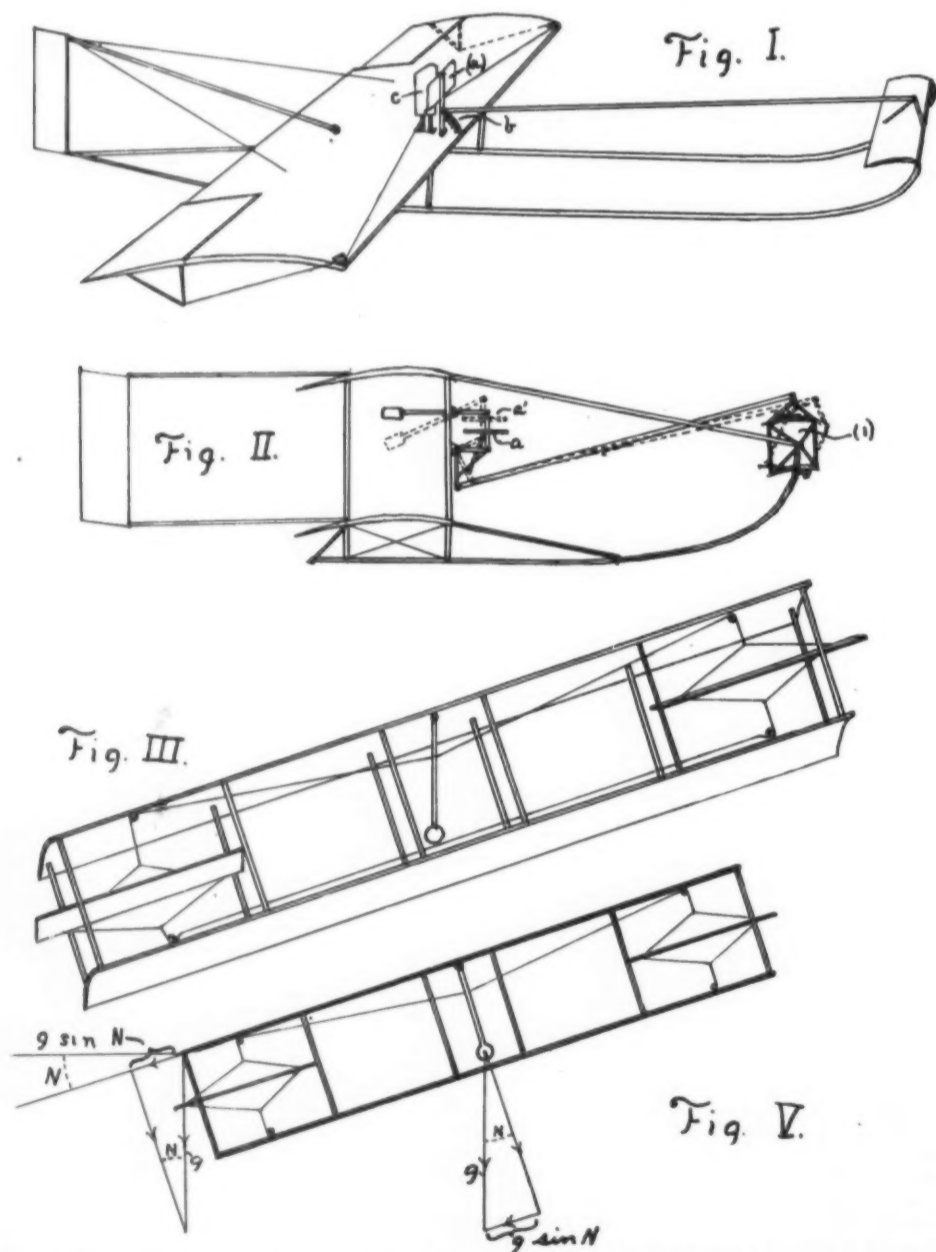


Fig. 1.—Automatic control by means of regulating planes. Fig. 2.—Form of control used by the Wright brothers. Figs. 3 and 4.—Diagram showing the fallacy of the pendulum control.

AUTOMATIC STABILIZERS FOR AEROPLANES

herent stability or by some controller which will automatically adjust the balancing surfaces.

The principle on which inherent fore-and-aft stability depends is comparatively simple. The center of gravity of the aeroplane is placed in front of the center of normal air pressure, and the forward planes are inclined upward at a greater angle to the line of flight than are the planes behind. If an aeroplane so adjusted be allowed to fall from a great height, since the center of gravity is in front of the center of normal air pressure, the front will turn down and the machine will dive toward the ground. Then, when it has gained sufficient speed, since the forward planes are turned upward, the front receives a proportionately greater air pressure and the machine rights itself. Whenever the aeroplane turns up in the air, its speed diminishes until the front again drops. In this manner its angle of flight through the air is kept constant.

There are two different principles by which inherent lateral stability is secured. The first of these is simply to bend up the outer ends of the wings at a dihedral angle, or to use vertical surfaces with a low center of gravity. Both of these constructions give the same result: The air pressure on the lower side is increased, thus making this side rise. The other method is somewhat more complicated. In this case there must be a vertical plane at some distance behind the center of gravity. Now if the aeroplane tips to one side, it will slide sideways until the air catches the vertical plane in the rear and turns it head into the wind. The result is that, instead of upsetting, the aeroplane merely turns around. If there is a constant upsetting force, however, the radius of the turn becomes smaller and smaller, and unless corrected by the controlling planes, the machine strikes the ground banked at a steep angle. But this principle works fairly well even in high winds, and is used on nearly all successful aeroplanes.

However, though in this manner an aeroplane may be made to keep its balance in still air, when winds arise troubles arise with them. Since the stability of the machine depends upon the reaction of the air upon it when the force of gravity pulls it one way or the other, whenever it is struck by wind gusts the balance is disturbed. For instance, just as when the aeroplane flies too rapidly through the air it turns upward until its velocity becomes less, so if a wind strikes it in front its speed through the air is increased and the front turns up, while if the wind comes from behind its speed through the air is diminished and it heads toward the ground. If the wind gust is sharp and the aviator is flying low, he may strike the ground before equilibrium can be recovered. Indeed, it is supposed that this is the manner in which Moisant was killed last December. The writer has found by innumerable experiments with models of every description that in general the closer the centers of normal air pressure and gravity are to each other the less the longitudinal stability is influenced by variable air currents. It is almost impossible for a well-balanced aeroplane to be completely overturned while in the air, but it may be easily tipped to an angle which is very dangerous, especially when close to the ground.

This means of obtaining automatic equilibrium is the only one in common use to-day, but we have just noticed that although it works very well in calm air, when it is used in the air-whirls of every-day flying, it becomes a source of danger rather than safety. If every time the aviator comes within 50 feet of the ground he is in danger of finding too quickly the bosom of Mother Earth, it will require a great deal of persuasion to convince the thinking man that the aeroplane is a practical and safe means of transportation. We must therefore, if we wish to make the aeroplane practical, so construct it that it cannot be tipped at a steep angle except at the will of the operator.

As was noted above, the constructors of all good flying machines are careful to have ample power in their controlling surfaces to counteract any movement of the center of air pressure caused by variable wind currents. So if we are able in any manner to set the balancing planes to counteract these changes, we will have perfect equilibrium at all times in the most choppy wind gusts. The controllers which are used to regulate the supplementary surfaces in this manner may be divided into three different classes: 1. Those which depend for their balancing properties upon the action of the air when the position of the aeroplane is altered; 2. those which depend upon the action of gravity, such as pendulums, and 3. those which depend upon some other force than gravity and the reaction of the air to control the balancing planes. We shall take up each of these classes in detail, explaining its action, pointing out faults and merits.

The most simple form of controller which depends upon the reaction of the air is that in which the longitudinal stability is regulated by a plane which is struck by a wind from the front, and the lateral stability by a plane which is acted upon by air cur-

rents from either side, as shown in Fig. 1. In this diagram, when the aeroplane turns down, the increased speed through the air makes extra pressure on the wind-plane *a*, and, forcing it back, turns up the horizontal rudder. If it turns up, the air pressure diminishes, and the spring *b* brings the plane forward and turns the rudder down. If the aeroplane turns to one side, it slides down edgewise until there is sufficient wind pressure on the vertical surface *c* for it to adjust the ailerons so as to regain balance. The fault with this style of controller is, however, very evident. Since the position of the balancing planes depends entirely upon the wind striking the controller, whenever any wind gust strikes the machine its stability is greatly disturbed. It is, indeed, much more sensitive to the pitfalls of the air than the machine which secures stable equilibrium by means of fixed supplementary surfaces as described above. Thinking to eliminate this trouble with wind gusts, the Wright brothers invented a controller for longitudinal stability, which keeps the flyer soaring at a definite angle of incidence instead of at a constant velocity through the air. The principle of this controller is shown in Fig. 2, which, however, leaves out the rather compli-

a horizontal position; but if it is only a few yards in the air, it will crash to the ground before it can regain its equilibrium. This one case is sufficient to show that the controller which is being considered is unsatisfactory.

We have shown, then, that the wind-plane cannot be used as a controller in either a horizontal or a vertical position. Let us now consider the pendulum in that capacity, as one of the class which depends upon gravity for its balancing powers. The intended action of this instrument, as shown in Fig. 3, is that when the aeroplane changes its position with respect to the direction of the force of gravity, the pendulum will remain vertical, and either by direct connections or by operating valves for compressed air, will set the balancing planes so as to re-establish equilibrium. One great difficulty with this device is that, when starting or stopping the machine, or when it is struck by wind gusts, the pendulum oscillates so violently that all stability is destroyed. But this difficulty is not insurmountable. These oscillations can be damped by friction or by a water basin, or a mercury level such as shown in Fig. 4 may be used in place of the pendulum. But even though these oscillations may

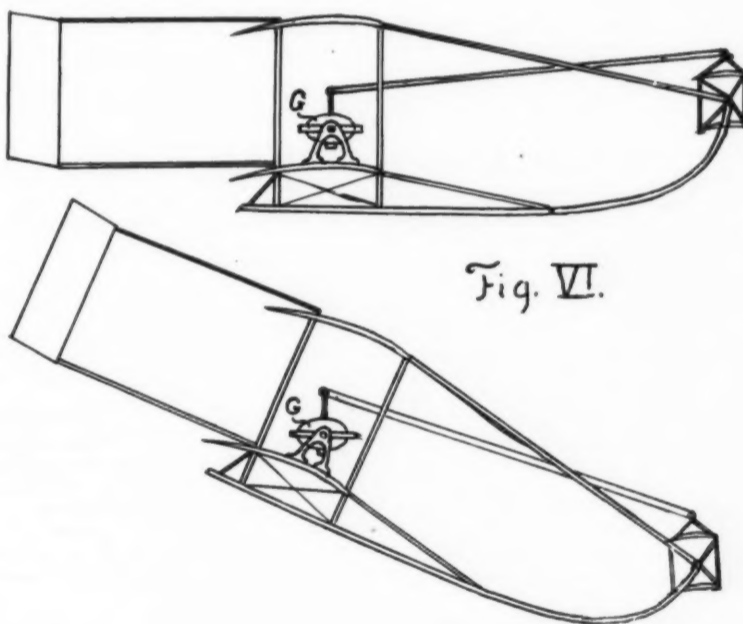
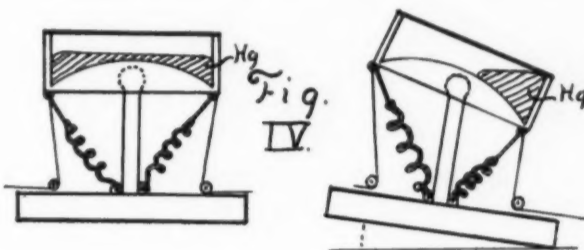


Fig. 4.—A mercury bath as a substitute for a pendulum. Fig. 6.—The gyroscope as used for automatically controlling the balancing planes.

#### AUTOMATIC CONTROLS FOR AEROPLANES.

cated compressed air connections which set the horizontal rudder according to the position of the controller. The regulating plane *a* is placed parallel to the plane of flight, and is connected by levers and rods with the elevator *l*. Whenever the aeroplane turns up, the wind strikes the under side of the controlling plane and the rudder is directed down, or *vice versa*. The Wright brothers have used this apparatus on their flyer with some success, although oscillations occur, especially in windy weather; they say they cannot trust it as well as themselves. The reason for this is clear. It is affected by wind gusts in much the same manner as was the other controller, though not as strongly. Let us consider just one case in which this device endangers the aviator's life. Suppose a sudden gust of wind strike him from behind. Since the speed through the air is decreased, the aeroplane will drop down, increasing the angle of incidence. The air striking the wind-plane directs the rudder down, thus turning the machine toward the ground. If it is allowed to go far enough, the velocity will be increased so that the angle of incidence will again become normal, and the aeroplane will resume

thus be made negligible, the pendulum when used as a controller does not preserve a vertical position except by the reaction of the air upon the aeroplane, and therefore cannot be successfully so used. This fact is illustrated by Fig. 5. If the aeroplane is tipped at an angle *N* there is an acceleration due to gravity, tending to bring the pendulum back to a vertical position, which is evidently equal to  $g \sin N$ . But supposing the resistance of the aeroplane to motion in a horizontal plane to be zero, when tipped at an angle of *N* degrees its acceleration in the same direction is also  $g \sin N$ , the same as that of the pendulum. This being the case, there is no force to change the latter's position with reference to the former. If, however, as is always the case, the aeroplane offers some resistance to motion in a horizontal direction, as its speed through the air under the influence of gravity is increased, the resistance will increase, and its acceleration will correspondingly diminish. The controller will then resume its perpendicular position, and by means of its connections adjust the balance of the flyer. But here we find our former difficulty: If it is only because of the air resistance that the con-

troller works, it will be affected by wind currents. For instance, if a sharp gust of wind should strike the machine from one side, it would blow the wings over, while the pendulum, owing to its inertia, would tend to remain in its original position, and would therefore swing toward the wind, raising the aeroplane on that side.

When we have considered these different types of controllers, we are brought to the following conclusion, which, when understood, is almost self-evident. Since the same cause always produces the same result, if when the aeroplane is tipped to one side it is turned back to its proper level by the action of the air due to its change of velocity or angle of flight through the air in that direction, then when an equal change in angle of flight or speed through the air is caused by some wind gust striking the machine, the position of the aeroplane will be affected in a similar manner. That is to say, if the position of the controller depends, as it does in the cases considered, upon the action of the air when the machine is tilted from normal level, when a similar action of the air occurs from a wind gust, its stability is similarly affected. For instance, when a flyer in stable equilibrium turns upward, its speed through the air is diminished and the front drops to the proper level, but when a wind strikes it from behind, its speed through the air is likewise diminished, and the front will again drop, but this time away below the proper angle of flight. Therefore, since we find that the stability of all machines balanced in a manner similar to those above described must depend upon the machine's reaction with the air, no such system of automatic equilibrium can be depended upon to preserve perfect balance while the aeroplane sails through the currents and cross currents met in actual flight.

We find it essential, therefore, that the controller shall be sensitive, not to the force or direction of the wind which strikes the machine, but to some other force which will move the controller with respect to the aeroplane when its equilibrium is disturbed. The only such forces of which the writer knows are the force of the earth's magnetic field acting on a magnetic needle, and the gyroscopic force of a rapidly rotating wheel. The magnetic needle is usually employed merely to point north, but since the earth's magnetic field tends to make it dip downward at an angle of about 75 degrees to the horizon, and

since this angle is almost constant in any locality, if the direction of flight is fixed, the magnet may be used to determine a horizontal position. This magnet may be made to operate the controlling planes by a system of electro-magnets and compressed air valves and pistons. Since both arms of the magnet have the same mass, neither gravity nor centrifugal force, due to oscillations of the aeroplane, would affect it in any way; but if vibrations should by any means be started, they would continue almost indefinitely and be transmitted to the flyer. Also in making turns, since the needle points down at 75 degrees instead of 90 degrees, there would be danger of losing balance. So, aside from its necessary frailness of construction, this instrument cannot make a suitable controller. It is therefore necessary for us to turn to the gyroscope to balance our flyer.

It is a well known property of the gyroscope that it tends to rotate continually in the same plane. If a force be made to act on the revolving wheel, its plane of rotation will be changed, but in a direction at right angles to the force, if the trunnions are frictionless. If by any means this precession at right angles to the force be increased, the gyroscopic action will overcome the turning force and move toward it. If, on the other hand, this precession be retarded, by friction or by any other means, the force will turn the gyroscope in the direction in which it acts. Gyroscopes constructed so that the precession is accelerated are the kind used to balance monorail cars. They are not adaptable to the aeroplane except when the latter is in unstable equilibrium with respect to gravity, and even then the controller would be affected by wind gusts. This would make flying very precarious in case the controller should get out of order.

When we consider a simpler form of gyroscope, however, that of a single wheel rotating in a horizontal plane, if, as is always the case, there is friction in the trunnions, the precession will be retarded and a force will be able to move the gyroscope slightly in the direction in which it is acting. Unless the friction is very great, the gyroscope will, however, strongly resist the forces which act against it. The balancing action of this gyroscope is shown in Fig. 6. Since it resists any force to change its plane of rotation from the horizontal, the gyroscope by suitable connections keeps the balancing planes set so as to correct any tipping of the aeroplane. But since

the trunnions are not frictionless, the forces required to operate the balancing planes would slowly turn the gyroscope from a horizontal plane. For this reason, if a gyroscope in neutral equilibrium with respect to gravity be used on an aeroplane, it will in time move far enough from normal position to dangerously tip the machine. In the same manner, if the gyroscope be set in unstable equilibrium, it will gradually move to a more stable position, upsetting the aeroplane with it. If, however, the gyroscope while rotating in a horizontal plane be in stable equilibrium, though its position may be slightly changed by the action of various forces, the force of gravity will be able slowly to bring it back to its original position, because of the friction of the supporting axes. We see then that this is the only condition in which the gyroscope can be relied upon to remain rotating in its original plane, and is the only condition in which it can be used to successfully balance an aeroplane.

When, however, a gyroscope in stable equilibrium is used, if it is affected by a force which changes its plane of rotation more than two or three degrees, the oscillations which it performs in returning to its original position disturbs the balance of the aeroplane quite perceptibly. Experimenters have found that these oscillations can be greatly diminished by the use of vanes in a water basin, but on a flying-machine the balancing planes answer very well the same purpose. If the gyroscope is connected directly to the balancing planes, as is shown in Fig. 6, it must be of comparatively great weight in order not to be disturbed by the forces acting upon it; but if instead of being connected directly to the auxiliary planes, it is used merely to open and close valves for compressed air to operate them, the forces acting on the gyroscope will be very small and the weight of the gyroscope may be greatly diminished. This controller is really a combination of a gyroscope and a pendulum, and is therefore slightly affected by wind currents. This disturbance is, however, insignificant, as long as the gyroscopic action is strong in comparison with the turning moment of the pendulum. A gyroscopic controller so constructed, with its plane of rotation regulated by gravity so that it is always kept constant, is capable, the writer believes, of setting the balancing planes so as to counteract every wind gust, and to keep its perfect balancing properties as long as the wheel is turning.

## The United States Reclamation Service

### Special Articles by the Engineers of the Projects

#### THE INTERMOUNTAIN DISTRICT.

By R. F. WALTER, Supervising Engineer.

The work of the Intermountain, sometimes known as the Central District of the Reclamation Service, covers a territory in which irrigation has been employed as a means of distributing moisture to grow crops since the earliest settlement by the pioneers, who, first attracted by the discovery of gold, in which all could not be successful, turned their attention to diverting the waters from the streams onto the barren land. So successful were they in this undertaking that agriculture soon became the chief resource of the territory, and quickly overshadowed the mining industry. Most of the builders have passed away; but the old canals constructed by the pioneers are still in use.

The original irrigation works were built merely to divert the flowing streams onto the parched lands; but the streams were so reduced in flow during the summer months, and there was so much water wasted during the spring months, that, after many years, some one suggested that the water going to waste might be run into reservoirs and stored for use after the streams had been reduced in flow, and also to make possible the extension of the irrigated area. The suggestions were considered at the time a huge joke, and the promoters called cranks. The building of reservoirs did not begin until about 1890, since which time thousands of storage basins have been put in use, and now on many of the streams no water escapes whatever, and the lower stretches of the river bed have become covered with trees and vegetation.

The work of the Reclamation Service in this district is scattered over the States of Colorado, Kansas, Nebraska, South Dakota, Oklahoma, and southern Wyoming, from an elevation of 2,500 feet above sea level to an elevation of over 10,000 feet, and from 38 degrees north latitude to 45 degrees, all in the neighborhood of the 105th meridian. The annual rainfall varies on the different projects from a normal of 6 or 8 inches to 16 inches, while in the mountains above the projects it may reach as high as 30 or 40 inches.

The crops produced are grain, alfalfa, potatoes, sugar beets, hay, and garden truck on all projects, while such fruit as apples, peaches, pears, and apricots are

very extensively grown on the southerly projects, for which there is always an excellent market. The value of the irrigated lands under these projects ranges from \$75 to \$100 per acre in the northerly projects to \$100 to \$1,000 in the southern projects, much of the land having sold for \$3 to \$10 per acre before the projects were inaugurated.

Below is given a brief description of the most important projects in this district on which work is being done by the United States Reclamation Service, the larger engineering features connected with each having been fully discussed above.

**Uncompahgre Project, Colorado.**—In the Uncompahgre Valley, in Montrose and Delta Counties, in southwestern Colorado, there is a body of very fine land of some 150,000 acres. The Uncompahgre River, which has a limited run-off, nearly all of which comes during the spring months, was sufficient for but a small part of this area. This valley was settled in the early eighties, and a succession of crop failures followed; and as there was no chance to store the flood water in any considerable amount, the inhabitants began to look elsewhere for relief, and discovered that the elevation of the Gunnison River was such that the water of that stream, which has a large run-off, could, by carrying the same through a tunnel, be diverted to the lands in this valley. The cost of such an undertaking, however, was so great as to be absolutely impossible by private capital. The State of Colorado was importuned to relieve the situation, and after spending \$25,000, turned the work over to the Reclamation Service in 1903, as it was too large an undertaking for them. The Reclamation Service has since completed this tunnel, which is six miles long, and it has been in use during the past two seasons. The old canals that have been turned over to the Government are being enlarged as fast as possible, and new canals and laterals built, so as to supply 140,000 acres with an assured water supply.

When fully developed the regular run-off of the Gunnison River will be augmented by the construction of a reservoir on Taylor River, which is a tributary of the same above the point of diversion. The reservoir will be built in the high mountains at an elevation of about 10,000 feet above sea level, and

will be filled during the spring and winter with water that would otherwise go to waste. The water will be let out during July and August, as needed to keep up the full flow through the tunnel.

**Grand Valley Project, Colorado.**—This project is located in Mesa County in western Colorado; and while the lower lands in the valley have been irrigated since about 1883, the irrigation of the higher mesas has only been talked of on account of the engineering difficulties encountered.

The higher mesas generally include the best and most fertile lands, but are the most expensive and difficult to reach with water—hence they are the last in every valley to be reclaimed. This is no exception here, and a high-line canal to reach the same requires a large investment and many engineering difficulties have to be overcome. The canal which has been planned by the Reclamation Service will furnish water to some 60,000 acres of irrigable land, from the flow of the Grand River, which is one of the largest streams in the district. The canal, which will run for several miles through the canyon, will involve rough and difficult construction, requiring several miles of tunnel, besides lined sections and heavy rock cuts. The water will be diverted from the Grand River by a diverting dam, which must be constructed so as to stop most of the water during low flow, and pass immense floods during high periods.

There will be required an extensive canal and distribution system below the canyon in order to get the water to each farm. This work will proceed rapidly as soon as the legal questions which have been delaying progress are settled.

**North Platte Project, Wyoming and Nebraska.**—One of the chief water courses in the middle West is the North Platte River, heading in the high mountains of Colorado, and flowing through Wyoming and Nebraska on its way to the Missouri. Although its flow is large during the spring months, it goes practically dry during the later summer months, and is generally limited in flow after July 1st.

With the organization of the Reclamation Service, one of the first investigations made was looking toward the conservation of these waters and the saving of them for use on the immense areas which the natural

flow of the stream could not begin to supply.

The Pathfinder reservoir site, located in south central Wyoming, was found to have such a capacity that all the flood flow which had heretofore gone to waste could be held back in most years, and turned out, as needed, later in the season. This reservoir has a capacity of over a million acre-feet, covering an area when full of 21,774 acres, with a maximum depth of water of 182 feet, this depth being made possible by the construction of the Pathfinder dam, which is a masonry dam rising to a height of 218 feet. The work on this reservoir has been completed for some time, and water has been stored for the past two seasons.

The lands selected to be watered from this reservoir are in Wyoming and Nebraska, and comprise an area of some 350,000 acres. The first unit, known as the Interstate, is nearing completion, and comprises about one-third of the total area. The second unit is known as the Fort Laramie unit, and comprises some 80,000 acres, on which work will start in the near future. The third unit of some 150,000 acres is now being investigated; but no allotments have yet been made for its construction.

The distribution system for these lands comprises substantial concrete diversion dams, large main canals, and lateral systems reaching each farm in the area.

**Belle Fourche Project, South Dakota.**—Surrounding the Black Hills in South Dakota are situated numerous bodies of land of more or less limited areas, which would be fine farming land if there was sufficient moisture; but as the rainfall is below what is needed to produce crops, these areas are practically unoccupied and of very little value. Numerous streams rise in the Black Hills, flow out through these areas toward the Missouri, but they flow very little water except during the spring months.

The Belle Fourche project, which is being completed, depends on the storage water of the Belle Fourche River during such flood periods, in a large reservoir which has been made possible by the construction of a large earthen dam across Owl Creek. The reservoir thus formed is about 100 feet deep, covering an area when full of over 8,000 acres, and it has a capacity for storing over 200,000 acre feet of water. This reservoir is at the head of about 100,000 acres of irrigable land. The water is diverted into the reservoir from the river by a large canal 70 feet wide on top, and carrying water 10 feet deep, with a length of only about six miles. The water is diverted from the river into the canal by a concrete diversion dam 400 feet long across the Belle Fourche River. From the reservoir two large main canals carry the water to the lands, and laterals are built from these canals to each farm.

#### WASHINGTON DIVISION.

By CHARLES H. SWIGART, Supervising Engineer.

THE Washington Division comprises all of the State of Washington and the extreme northern part of Idaho. The Reclamation Service has completed one project, the Okanogan, and is now constructing the Yakima project.

**Okanogan Project.**—The Okanogan project, a reconnaissance of which was made in 1903, construction being started in April, 1907, and completed during the latter part of 1910, provides for the irrigation of land in the valley of the Okanogan River between Riverside and Okanogan, Wash. Water is stored in Salmon Lake and Conconully reservoirs, which have a combined capacity of 15,000 acre feet. The former is a narrow body of water three and a half miles long, located on a tributary of the North Fork of Salmon Creek. Water from this lake is discharged through a small concrete structure, with an opening 3 feet wide, into a natural channel leading to Conconully reservoir, which reservoir is formed by an earth dam 1,000 feet long, 64 feet high, containing 336,000 cubic yards, built across Salmon Creek a short distance below the confluence of the North and West Forks. The dam was constructed by hydraulic fill method, and is the only one so far constructed in that manner by the Reclamation Service, the work being done by force account. The dam has a top width of 20 feet, the slope on the upper face is 3 to 1, on the lower face 2 to 1. The main part of the dam rests on a foundation of well compacted sand and silt and clay. The center of the embankment consists of sand and silt with a puddled core of selected material. A line of wooden sheet piling was driven 70 feet upstream from the center of the dam to prevent percolation. A tunnel 8 feet square through a granite hill near the east end of the dam provides an outlet for the reservoir. The discharge through the tunnel is controlled by two 36-inch gates operated from a concrete gate house. A spillway 180 feet long with a crest 10 feet below the crest of the dam is located in a rock ridge 300 feet beyond the west end of the dam. The channel of Salmon Creek is used for a distance of 12 miles below Conconully reservoir, at which point the water is diverted

into the main canal, which has a capacity of 100 second feet. The irrigable land under the project, amounting to approximately 8,650 acres, has an elevation of 1,000 feet above sea level. The character of the soil is volcanic ash, sand, and gravel. The duty of water has been determined as 2½ acre feet per acre per annum, the irrigating season lasting 123 days. The principal products are fruit, hay, grain and vegetables. The building charge per acre has been announced as \$65, and the annual maintenance and operation charge as \$2.

**Yakima Project.**—The Yakima project embraces all of the lands in the Yakima Valley that can be watered from United States Reclamation Service works, and in addition some lands in the Columbia Valley lying near the mouth of the Yakima River. This project for convenience is divided into Storage, Kittitas, Tieton, Sunnyside, and Wapato units, with the High Line including the Benton Unit or the Benton Unit alone as alternative propositions.

The Storage Unit includes the construction of works for the impounding of the flood waters of the Yakima River and its tributaries in reservoirs at Kachess, Keechelus, Clealum, and Bumping lakes and McAllister Meadows.

At Kachess Lake the construction by force account of an earthfill dam with concrete corewall was begun in 1910, and will be completed in 1912. The dam will have a maximum height of 68 feet, a crest length of 1,500 feet, and a volume of about 250,000 cubic yards. The spillway, which will be 250 feet long and 58 feet above the stream bed, will have a capacity of 7,200 second feet.

At Keechelus Lake an earthfill dam with a maximum height of 64 feet, a crest length of 6,400 feet and a volume of about 480,000 cubic yards, is proposed. The spillway at this lake will be 287 feet long and 54 feet above stream bed.

At Clealum Lake an earthfill dam is projected with a maximum height of 140 feet, a crest length of 1,200 feet and a volume of 660,000 cubic yards. The spillway at this lake will be 400 feet long, 130 feet above stream bed.

At Bumping Lake the construction by force account of an earthfill dam with puddled core was begun in June, 1909, and completed in November, 1910. The maximum height of this dam is 45 feet, length of crest 3,500 feet, volume 233,800 cubic yards. A spillway 235 feet long and 40 feet above stream bed provides for the discharge of excess flood water. The outlet works consist of a concrete outlet conduit, concrete gate tower, and two sets of cast-iron gates, each 4 feet by 5½ feet.

At McAllister Meadows there has been projected a high dam in the Tieton River, near the confluence of the North and South forks.

These five reservoirs constitute the principal storage possibilities of the Yakima project, and will have a total capacity when fully developed of approximately 928,000 acre feet. There are, however, several secondary sites available which will probably be developed as necessity requires.

The Kittitas Unit embraces some 62,000 acres of land lying along both sides of the Yakima River, near the town of Ellensburg. Surveys and investigations of this unit have been made by the Reclamation Service, but it is probable that the further development of the unit will be undertaken by an organization of the land owners.

The Tieton Unit, containing some 34,500 acres, lies west of the city of North Yakima and between the Naches River and Ahtanum Creek. Water for this unit is taken from the Tieton River about 15 miles above its confluence with the Naches River. The main canal is located along a very steep sidehill of the Tieton Canyon, a distance of 12 miles, in which are included two miles of tunnel. The entire length of the canal is lined with concrete made in 2-foot semi-circular sections with a diameter of 8 feet for open canal and 2-foot circular sections with a diameter of 6 feet for tunnel. These sections were cast at suitable sites in the bottom of the canyon, transported to the canal, set in place, and jointed. The construction of the Tieton Unit is nearly completed. The building cost per acre has been announced as \$93, with an operation and maintenance charge of \$1.50 per acre per annum. The character of the soil is volcanic ash. The principal products are fruit, forage, and hops. The duty of water has been determined as 2.17 acre feet per acre per annum, the irrigating season lasting about five months.

The Sunnyside Unit, containing 100,000 acres, receives its water from the Yakima River, just below Union Gap. The canal system was originally constructed by private capital, and was purchased by the Reclamation Service in 1905. The main canal, which is about 69 miles long, and which originally carried about 650 cubic feet per second at the intake, is now being enlarged to a maximum capacity of 1,076 second feet.

Other improvements have been made by the Reclamation Service, including the construction of a concrete diversion dam, concrete drops in the main canal, and three wasteways which will also serve as drains for the low lands. The system has also been extended, by means of two siphon lines, across the Yakima River, to include lands near the towns of Mabton and Prosser. The construction of the Sunnyside Unit will be completed in 1912. The building cost has been announced as \$52 per acre, with an operation and maintenance charge of \$0.95 per acre per annum. The character of the soil is volcanic ash and gravel. The principal products are forage, hops, vegetables, and fruit. The duty of water has been determined as 3 acre feet per acre per annum, the irrigating season lasting about seven months.

The Wapato Unit consists of 114,000 acres on the right bank of the Yakima River, just below Union Gap. This land was allotted to the members of the Yakima tribe of Indians. At present there are about 32,000 acres partially irrigated by a system built by the Indian Service. Surveys and investigations for the complete development of this unit have been made by the Reclamation Service.

The Benton Unit includes from 120,000 to 150,000 acres of land on both sides of the Yakima River, near its junction with the Columbia. The original plan proposed the diversion of water from the Yakima River, near Prosser, but in the event the High Line Canal is constructed the Benton Unit will be watered from the Columbia River.

The High Line Canal will, if constructed, furnish water for the lands on the left bank of the Yakima River above existing canals. Reconnaissance surveys only have been made in connection with the Benton and High Line units.

#### NORTHERN DIVISION, U. S. RECLAMATION SERVICE.

By H. N. SAVAGE, Supervising Engineer.

THE Northern Division comprises the States of Montana and North Dakota, and northern Wyoming, and includes the Missouri River drainage basin, with the Yellowstone River in Montana and the Big Horn River in Wyoming. Within this area the construction of seven Reclamation Service irrigation projects has been authorized. Construction has progressed to the extent that at least one unit of each project has been completed, and all the large feature structures on several of the projects are now constructed. Two of the projects have been practically completed, and all seven of the projects, in so far as completed, have been put under operation, six of them now having been operated for three consecutive seasons. Funds have been provided sufficient to complete the smaller projects and also the works to cover the major portion of the lands contained in the larger projects.

The flat grade of the Missouri River rendering the construction of gravity irrigation canals impossible, the construction of the *North Dakota Pumping Projects* was found to be dependent upon the development of power from the ample fuel supply in local lignite beds and its transmission electrically to operate centrifugal pumps mounted on floating barges on the Missouri River. The barges are taken out of the stream at the end of the season and again launched at the beginning of the next irrigation season.

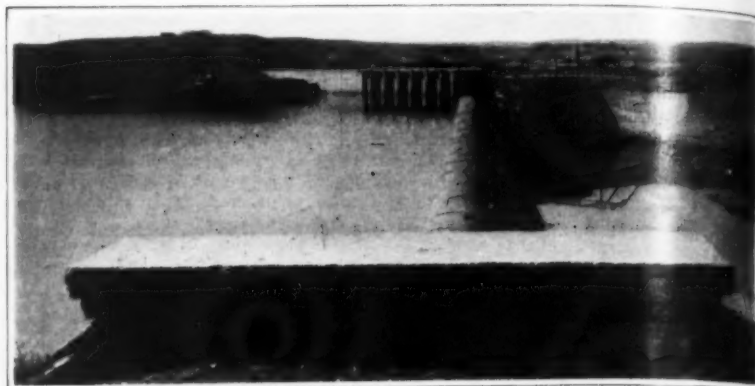
The Buford-Trenton and Williston pumping projects have been completed to irrigate 20,000 acres, and may ultimately be extended to cover twice this area, or more.

**The Lower Yellowstone Project,** in Eastern Montana and North Dakota, covers 60,000 acres, and is nearly completed. The main canal, on account of the geologic formation encountered, has involved many and difficult engineering problems both in construction and operation and maintenance, as have also the unusually great number of cross-drainage structures, all of which are of masonry construction. The principal feature structure is the diverting dam, which has a crest length of 700 feet, with a height of 12 feet, and is of timber crib rock-filled type. Provision has been made for an overflow depth of 25 feet in anticipation of the frequent ice gorges. The Yellowstone River at the site of this dam has a maximum flood flow of 160,000 cubic feet per second.

**The Shoshone Project,** in northern Wyoming, is designed to reclaim 164,000 acres of land. The works are feasible of extension to cover a total area of 300,000 acres, including the Oregon Basin tract, the available water supply being ample for this area. The principal feature structures are the Shoshone Dam and the Corbett tunnel. The Shoshone dam, the highest masonry dam in the world (328.4 feet), with its reservoir, just now for the first time filled to the spillway, is designed to regulate the entire discharge of the two Shoshone rivers, which have their source in the mountains forming the "Crown of the Continent," within and east of the Yellowstone National Park. The



Picking Strawberries 1½ Miles South of Boise. Payette-Boise Project, Idaho.



The Diversion Dam and Intake of the Main Belle Fourche Canal, South Dakota.



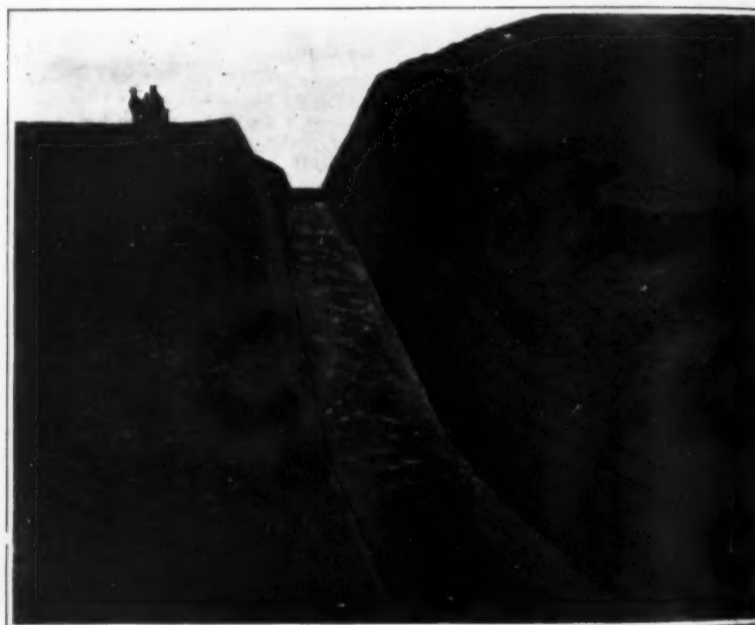
Shoshone Project, Wyoming. The Desert Before Irrigation.



Payette-Boise Project, Idaho. Main South Canal Completed.



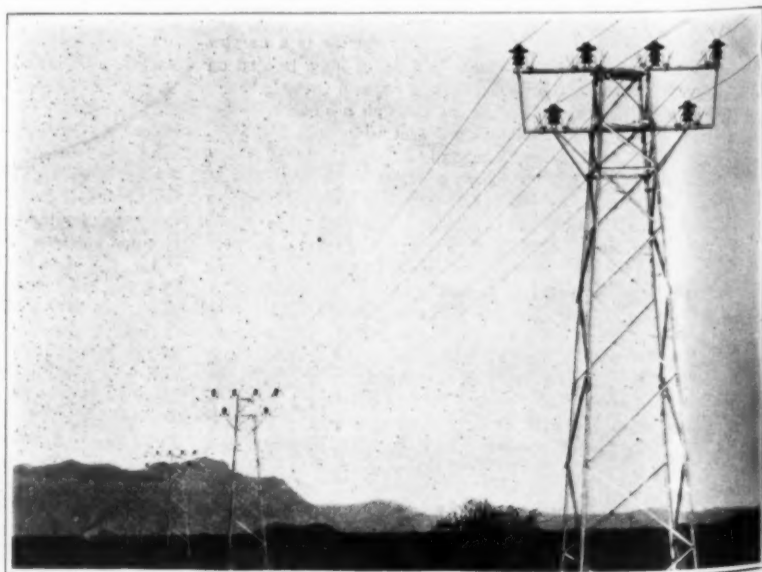
Shoshone Project After Irrigation. The Town of Powell, Three Years Old.



Uncompahgre Project, Colorado. Largest Drop in the South Canal



Inside View of Cottonwood Flume. Interstate Canal, North Plate Project, Nebraska.



Transmission Towers Crossing Desert Between Roosevelt Dam and Phoenix.



Umatilla Project, Oregon, Showing the Desert in 1905.



What Irrigation Did in Five Years in a Fruit Orchard of the Umatilla Project, Oregon.



Road in Shoshone Canyon. View Looking Up Canyon Toward Dam Site.



View on the Wagon Road Directly Above the East Wall of the Salt River Dam Site.



Sluiceway on the Yuma Project, Laguna, Arizona.



Concrete-lined Rock Section of the Main Feed Canal, Umatilla Project, Oregon.



The Arizona Desert Before the Salt River Project Was Begun.



Six Years After the Salt River Project Was Begun. Land Worth \$650 an Acre.

Corbett tunnel has a capacity of 1,000 cubic feet per second, and is 3½ miles long. Two million dollars has been appropriated with which to continue the work on this project.

**The Huntley Project.**—On the Yellowstone River, immediately east of Billings, is an area of 32,000 acres. More than 80 per cent of the first unit of 28,000 acres is now settled, the farms having an average area of about forty acres of irrigable land. So far as data of results in similar undertakings are known, the uniform success of the Huntley settlers is unprecedented. The crops produced on the entire irrigated area the second season had a value of upwards of \$25 per acre. The value of the sugar beets produced on many of the fields averaged over \$100 per acre, and this season upward of 1,000 carloads of sugar beets will be produced. The project now has thirteen public schools and six church organizations. It has the advantage also of two transcontinental railroad lines extending throughout its length. The last unit of the project is about to be put under construction.

**The Sun River Project,** west of Great Falls, is the largest in the division, the area of land being limited only by the available water supply, which, in turn, is adequate for between 200,000 and 300,000 acres. The first or "Fort Shaw" unit of the project has been completely constructed, and about four-fifths of its area is settled. It is now entering upon its third season of operation. An allotment of \$3,500,000 has recently been provided for carrying forward construction work, the main features of which will be a number of high storage dams and a main canal with a capacity of 2,500 cubic feet per second.

**The Milk River Project,** in northern Montana, is one of the first projected by the Reclamation Service, construction having been held in abeyance pending the negotiation of a treaty providing for the apportionment of the waters of the Milk River and the St. Mary River drainage basins as between Canada and the United States. The Milk River project is dependent for its water supply upon the waters of the St. Mary drainage basin, which waters now run northerly and discharge into Hudson Bay. This project involves the irrigation of upwards of 200,000 acres of land. A satisfactory treaty has now been accomplished, and an allotment of \$4,000,000 has recently been provided for carrying on the work.

**Indian Reservation Irrigation Projects.**—The Reclamation Service is constructing irrigation works on three Indian reservations in the Northern Division, viz., the Flathead, Blackfoot, and Fort Peck. Each of these has an area of about 150,000 acres of irrigable land. The engineering layout of these irrigation systems provides for the ultimate reclamation of all of this land. The major portion of the irrigable area has been allotted to the Indians in severalty. The receipts from the sale of excess lands will return the cost of the irrigation works. The Indians as laborers and with their teams are performing a large amount of the work, for which they are paid rates current for similar service. One hundred and seventy-five Indian teams have been employed on the Fort Peck Project, and 151 four-horse Indian teams were employed at one time this season on the Blackfoot project.

The ultimate development of the Flathead Project involves the construction of fifteen storage reservoirs to conserve the available flood runoff from the several creeks which have their source in the Mission Range, and the construction and operation of a hydro-electric pumping plant. Upward of 200,000 acres of this reservation, including the major portion of the irrigable land, have been allotted to the Indians, in addition to which there have been reserved for the benefit of the tribe power possibilities within the reservation which are susceptible of developing over 300,000 horse-power; and 200,000 acres of timber land which now carries 1,250,000,000 feet board measure of merchantable timber.

#### IDAHO DISTRICT.

By F. E. WEYMOUTH, Supervising Engineer.

**The Idaho District** embraces that portion of the Snake River Basin from its headwaters in the Yellowstone National Park in Wyoming to its confluence with and including the Salmon River, a total area of about 90,000 square miles. The main office is located in Boise, Idaho's capital and largest city. The work of the district is divided among three projects—Boise, Minidoka and Snake River Storage.

**Boise Project.**—This embraces 243,000 acres of land on the south side of the Boise River, between its confluence with the Snake River and the city of Boise. The soil here consists of a volcanic ash and a sandy loam, rich in plant food and suitable for a variety of crops. Fruits of all kinds, as well as grains and vegetables, thrive in this locality. The average rainfall is about 13 inches per year, or about one-third of the amount necessary for the production of the best crops.

The project is traversed by the main line of the

Oregon Short Line Railroad, and also by the branch line from Nampa to the city of Boise. There is an electric line between Boise and Caldwell, and another one operating between Boise and Nampa. This latter line is soon to be extended on to Caldwell. The principal engineering features are the storage and diversion dam, the concrete-lined section of the main South Side Canal and the dams for the Deer Flat reservoir.

The storage dam, located 22 miles from Boise, now under construction, will, when completed, be the highest dam in the world. Its principal dimensions will be as follows: Length of crest, 1,025 feet; height above foundation, 340 feet; width of roadway, 15 feet; thickness at base, 265 feet; and volume, 485,000 cubic yards. This dam will impound 207,000 acre feet of water, to be used during the low-water period of the year for lands embraced in the upper portion of the project. The lower portion of the project is supplied with stored water from the Deer Flat reservoir, located within the project, and formed by building two embankments containing about one million cubic yards of earth each across the lower end of a valley near the center of the project. The water supply for this reservoir is diverted from the Boise River and delivered through the main South Side canal. The capacity of this reservoir is 170,000 acre feet.

The diversion dam and headgates for this project are located at the mouth of the canyon on the Boise River, about seven miles above the city of Boise, and consist of a 216-foot overflow weir of solid masonry 35 feet above the river bed, flanked on the south side of a logway 30 feet wide, a fishway, two diverting tunnels having 5 by 10-foot gates, and the headworks to the main South Side canal composed of eight 5 by 9-foot gates. The main South Side canal has a capacity of 2,500 second-feet and is 40 miles long. Six miles of this canal is lined with concrete.

**Minidoka Project.**—This embraces an area of about 132,000 acres of land on both sides of the Snake River, in the central southern part of the State of Idaho. The soil here consists of volcanic ash and sandy loam similar to that on the Boise project, but containing more sand. Vegetables, hay, and grain are the principal crops. The average rainfall is about 14 inches.

The project is traversed by the Minidoka and Southwestern branch of the Oregon Short Line Railroad; also by a branch of the Oregon Short Line extending from Rupert to Bliss; another branch from Burley to Oakley, and still another is now being constructed from Burley eastward, through that portion of the project lying south of the Snake River. This road will open up the Raft River country; thence proceeding in a southerly direction and connecting with the main line of the Oregon Short Line just east of the Great Salt Lake.

The principal engineering features in connection with this project are the Minidoka dam, headworks, power plant, and pumping stations. The dam is of the rock-filled type, 736 feet long, 25 feet wide on top, and 86 feet high, flanked by the power plant and north side headworks on the north and the spillway of solid concrete, 2,400 feet long, 2 to 15 feet high, and south side headworks, on the south side.

At the power plant there are five 2,000 horse-power turbines direct connected to as many 1,500-kilowatt generators. The power generated is used for pumping water to 47,000 acres of high land during the irrigating season and for furnishing the towns on the project with light, power and heat.

Owing to the large amount of power available in the winter months, power for heat is furnished to the towns at a rate which successfully competes with coal and wood. Nearly all of the business houses and many of the private houses in the thriving towns of Rupert, Heyburn, and Burley use electrical energy for heat.

There are three pumping stations on the south side of the river, called the first, second, and third lifts. At the first lift there are four 125 second-foot pumps, at the second three 125 second-foot pumps, and at the third one 125 second-foot and one 75 second-foot pumps, all operated by electric motors supplied with power from the main plant at the Minidoka dam. The first lift pumps 500 second-feet of water from the south side gravity canal to the first lift canal, 30 feet higher; the second lift forces 375 second-feet 30 feet higher; and the third lift raises 200 second-feet 30 feet higher still. The machinery at the lifts and at the power plant is installed in neat buildings of reinforced concrete. The spillway is provided with reinforced concrete piers 8 feet high and 8 feet on centers, by means of which the surface of Lake Walcott, formed by the dam, can be raised five feet, thus increasing the storage capacity of the lake and the available head of water on the turbines.

**Snow River Storage.**—This contemplates the storage of flood waters of the river in reservoirs in order to regulate its flow so as to conform as far as possible to the needs of irrigation and power. The only reser-

voir so far constructed is at Jackson Lake, just south of the Yellowstone National Park. Here a reinforced concrete dam, 28 feet above stream bed and 200 feet long, terminating on the end in an earth dike 3,000 feet long, has been built across the outlet of the lake, thus forming a reservoir of 380,000 acre feet capacity. The water from this reservoir is delivered to the Minidoka project during the low water period of the Snake River.

#### The Chemistry of Mummification

MR. A. LUCAS has rendered a great service to all who are interested in the customs of the ancient Egyptians and in the history of the methods adopted for the preservation of the body by collecting into one convenient volume the results of his investigations concerning the "Preservative Materials Used by the Ancient Egyptians in Embalming," which has been issued as Survey Department Paper No. 12 (Cairo).

More than seventy years ago Dr. Pettigrew published an exhaustive account of the chemistry of mummies, so far as this was possible at that time, and he had the assistance of Michael Faraday in his investigations. Since then the whole subject of mummification had fallen into the hands of archaeologists, who invented a curious alchemy of their own for the purpose of interpreting the accounts of Egyptian embalming given by the ancient Greek writers; but during the last ten years this era of sensationalism has received its quietus, and a serious attempt has been made to elucidate by recognized scientific means the nature of the methods of mummification.

Recent investigators have had the immense advantage of having many hundreds of mummies of known age and provenance for every unknown mummy that came into Pettigrew's hands; and the enormous strides in chemical knowledge that the last seventy years have witnessed have made it possible to obtain much more information from the material than was possible before. Most of the embalming materials thus rescued have been analyzed by Prof. W. A. Schmidt, of the Cairo School of Medicine, and Mr. Lucas, analyst to the Egyptian Survey Department, and the results of their work have been published in various scientific journals published in Egypt and Europe. Mr. Lucas has collected all this scattered information and added to it in this valuable report. He has also given an extensive bibliography, which, though not quite complete, will be of very real service to archaeologists, who in the past have been at a loss to obtain accurate information upon such matter as are discussed in this work.—*Nature* (London).

#### Development During Exposure

CERTAIN important advantages can be gained by combining the operation of development with the exposure of silver bromide pictures. When it is attempted to make enlargements from a hard negative, the results are often worthless, owing to the fact that the paper tends to increase the hardness. By the usual method of exposing and subsequently developing, it is possible to obtain two kinds of results. Either the exposure is calculated for the shadows, in which case a picture is obtained which shows out well in the shadows but lacks detail in the highlights; or else the exposure is adjusted for the highlights, when these bring out the details, but the shadows appear ink black. It is impossible to bring out both lights and shadows together. A remedy seems to be found in a new process described by Mortimer, and recently improved and tested by O. Mente, and noted in a recent number of *Prometheus*. The silver bromide paper is simultaneously exposed and developed, using an enlarging apparatus fitted with artificial light and condenser. The copying paper is dipped in a developer to which glycerine has been added, is placed in the enlarging camera, and given a short exposure such as is required to properly bring out the shadows. The exposure is then stopped by placing a mat red glass in front of the objective; in the diffuse inactinic light which is thus transmitted the development of the shadows can be closely followed with the eye. The paper is now remoistened with a broad brush, and a further exposure is given, of about fifteen times the duration previously given for copying the highlights in the picture; in this process the shadows remain almost unchanged, since the reduced silver underlying these portions from the previous development protects them from further exposure. The process is said to be easily carried out and to be almost universally successful.

We learn from the Trinidad *Royal Gazette* that beginning July 1st, 1911, standard time, four hours later than Greenwich mean time, was officially adopted in the colonies of Trinidad and Tobago. This change was part of the programme of adopting uniform time throughout the British West Indies and British Guiana.

## Substitution of Lumber

### How Inferior Material is Passed Off for Better

A substitute is something that is offered or sold in place of another material. There are many kinds of woods bought and sold that are designed to take the place of another, usually of a superior kind. Thus, cottonwood (*Populus deltoides*), sold as basswood (*Tilia americana*), is a commercial substitute, but it is not an equivalent substitute, which should be timber nearly or quite equal or similar in its commercial value to the one it replaces. The contractor may in meeting specifications for white oak (*Quercus alba*) substitute bur oak (*Quercus macrocarpa*) as an equivalent substitute. If Douglas fir (*Pseudotsuga taxifolia*) were delivered when western yellow pine (*Pinus ponderosa*) is called for, this would be a kind of substitution that is unequal and fraudulent substitution. It is with this phase of the subject that this paper mainly deals.

A great majority of wood users are not aware of the enormous amount of unequal substitution that is constantly going on, even with our most common native commercial woods. Although the literature of the timber trade is not filled with exposures of very serious impositions on the buying public, the facts nevertheless remain, and no one is perhaps better informed on the enormity of the problem, and extent to which such unequal substitutions are knowingly practised, than the men who are frequently called upon to make identifications for wood-using concerns. There is, however, a great deal of substitution that is evidently unintentional. Yet ignorance or indifference on the part of one placed in a responsible position and who should know is hardly excusable. The reasons for this are numerous, and often more or less complicated. The careless use of common names is perhaps the chief cause. Yellow pine is a name applied locally to no less than six species of pines; and when a retail lumber dealer calls for yellow pine, the wholesaler is liable to fill the order with any one of the half-dozen kinds he has in stock. The dealer generally supplies the kind which yields him the largest profit. In a great many cases local dealers do not know the distinguishing characteristics of the various woods they are handling, nor are they particularly concerned so long as they are able to sell satisfactorily what they have in stock. It is the same in the case of lumber as it is in all other cases where unfair means are practised to obtain a large profit, the general public has to pay for it. Large concerns having special uses for certain woods usually have competent men to inspect all woods before they are accepted, and are, therefore, not obliged to pay for what they do not get. If it costs \$200 per 1,000 feet to get mahogany (*Swietenia mahagoni*) from Honduras to the local markets, and \$75 for crab wood (*Carapa guianensis*) from British Guiana to similar markets, it does not seem fair to charge the general public as much for the crab wood as for the mahogany, simply because the dealer chooses to apply the name "mahogany" to the inferior crab wood. Numerous cases of this kind could be cited.

Substitutions of timber are practiced the world over. This is especially true with certain useful kinds of timber now becoming scarce, such as mahogany, ebony (*Diospyros ebenum*), sandalwood (*Santalum album*), box (*Buxus sempervirens*), and rosewood (*Balsergia nigra*). Dealers in fancy woods are often unable to distinguish what woods they have in stock, for in the case of mahogany alone there are fully twenty-five different woods now sold for this timber, and no less than ten different species that are known as rosewood. The layman is still less able to tell

apart the so-called mahoganies and substitutes for other wood after they have been properly stained and finished. Users of ebony, cocobola (leguminous tree), sandalwood, orange (*Citrus vulgaris*) and box must be on the constant lookout to avoid inferior substitutes. Caution must be exercised also to avoid substitutes for woods used in the medical profession, such as cinchona (*Cinchona calisaya*), witch-hazel (*Hamamelis virginiana*), and woods from which certain dyes and resinous substances are obtained.

There are less than one hundred native woods that are commercially important, and one can but be astonished at the amount of substitution there is constantly going on, and almost invariably without the knowledge of the consumer. So closely do some of these woods resemble each other, that an expert is often baffled and confounded in attempting to tell them apart. Some of the chief woods for which other woods are frequently substituted are as follows:

White pine (*Pinus strobus*).—The lumber of young trees of red pine (*Pinus resinosa*) having large proportion of sap, is often sold as white pine; older trees frequently develop reddish heartwood, a character often precluding its substitution for white pine. Sugar pine (*Pinus lambertiana*) is at present shipped to Eastern markets, and is invariably retailed as white pine. Expert graders occasionally select lumber from the western yellow pine (*Pinus ponderosa*) and from Douglas fir (*Pseudotsuga taxifolia*) in carload lots which are sold as white pine. Western white pine (*Pinus monticola*) is also a very common substitute for eastern white pine.

Longleaf pine (*Pinus palustris*).—Chief among the substitutes for this species is loblolly pine (*Pinus taeda*). Probably no two timbers in this country are so often confounded as these, and it requires an expert to tell them apart. Sometimes they are so nearly alike that it is impossible to separate them without the aid of the compound microscope. Shortleaf pine (*Pinus echinata*) is difficult to be distinguished from longleaf pine, especially the timber of old, mature trees, which is invariably mixed with and sold as longleaf pine. The persistent efforts on the part of mill men to mix shortleaf and loblolly with longleaf pine has caused controversies without end. One species in the South Atlantic and Gulf States that may be regarded as an equivalent to longleaf is slash pine (*Pinus heterophylla*). The wood of this species is harder and more durable than that of longleaf pine. Elliot's pine (*Pinus elliotii*) in extreme southern Florida, is another equivalent substitute, but the wood may be readily distinguished from that of the other southern pines by its extreme hardness and very resinous character.

Western yellow pine (*Pinus ponderosa*).—This is the most important so-called yellow pine in the Rocky Mountain and Pacific Coast regions, and is sold in practically every retail lumber yard west of the Mississippi River. The supply is by no means limited, and the prices for the different grades have not soared above that of other timber of similar or nearly similar importance. There are, however, certain species of pines that are being substituted, but this chiefly takes place in the mills or at the place from which the lumber is originally shipped. Jeffery pine (*Pinus jeffreyi*) and western yellow pine are seldom kept separate, for this is hardly expected in a case where the two species are so closely related that certain botanists concede to the fact that they are one and the same species. Practically all the timber of yellow pines growing within the range of western yellow pine are

substituted for it. Chief among these may be mentioned lodgepole pine (*Pinus Murrayana*); knobcone pine (*Pinus muricata*); Chihuahuan pine (*Pinus chihuahuana*), and Arizona pine (*Pinus arizonica*).

Red spruce (*Picea rubens*).—The shades of difference that separate the wood of red spruce from that of white spruce (*Picea canadensis*) and black spruce (*Picea mariana*) are so slight that they are seldom recognized. Black spruce is not very important commercially. Both the black and white spruces have shorter fibers and are less desirable for the purpose for which red spruce is chiefly used, namely, for paper pulp. Another substitution for red spruce is balsam fir (*Abies balsamea*), but chiefly for use in the pulp mills. Formerly balsam fir was rejected, but through the persistent effort on the part of lumbermen to mix balsam fir with spruce the paper mills have conceded to accept a certain percentage.

Hickory (*Hicoria alba*).—The kind preferred by hickory users is the mockernut or white hickory, but the wood of shagbark (*Hicoria ovata*) and pignut (hickory) (*Hicoria glabra*) so closely resemble the mockernut that it is very difficult to distinguish the three kinds in a pile of lumber. In most cases all the merchantable trees are cut regardless of species, and the wood sold for whatever kind the purchaser happens to ask.

Common cottonwood (*Populus deltoides*) is the principal species of the cottonwoods, and is largely used for making crates and packing boxes. The wood of certain species of willows (*Salix*) are substituted for cottonwood, but only to a very limited extent. The growing scarcity of basswood (*Tilia americana*) has attracted the attention of a certain class of wood users who are now testing cottonwood with a view to use it in place of basswood.

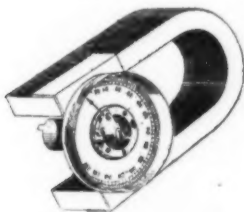
Paper birch (*Betula papyrifera*) has a wide range of distribution and is used for a great variety of purposes. The yellow birch (*Betula lutea*) and sweet birch (*Betula lenta*) are also widely distributed, and their woods are sold one for the other. The wood of the different species are seldom kept separate, and only experts can tell them apart.

White oak (*Quercus alba*).—It is often difficult to distinguish the woods of the different oaks belonging to the so-called white oak group. Among the chief kinds that are frequently substituted for white oak are cow oak (*Quercus michauxii*), swamp white oak (*Quercus platanoidea*), chinquapin oak (*Quercus acuminata*), chestnut oak (*Quercus prinus*), overcup oak (*Quercus lyrata*), and bur oak (*Quercus macrocarpa*). These oaks possess similar or nearly similar properties, and the purchasers are likely to get any one of these on the market when they specify white oak. It is more difficult to substitute woods of the red oak group without being detected. Chief among these are red oak (*Quercus rubra*), Texan oak (*Quercus texana*), scarlet oak (*Quercus coccinea*), yellow oak (*Quercus velutina*), pin oak (*Quercus palustris*), and Spanish oak (*Quercus digitata*).

The importance of this problem can be comprehended only by men who have practical experience in connection with the identification of woods and the literature bearing thereon. The literature is as yet very limited, for the reason that until the present a study of wood structure for the purpose of identification has received very little attention. It is the man with the compound microscope and with a microtome that cuts microscopic sections of wood one twenty-five-hundredth of an inch in thickness who can tell wood users whether a certain sample is true to name or not.

#### Measuring the Strength of a Magnet

The comparative strengths of horseshoe magnets and the gradual loss of strength by the same magnet can be easily measured with a simple magnetoscope,



Simple Magnetoscope.

consisting of a graduated disk which is attached to a shaft turning on bearings in a bridge connecting the poles of the magnet. At the center of the disk is a steel needle, which is brought back to the zero mark by a spiral spring. All parts except the needle are

made of brass or other non-magnetic material. The instrument is placed with the zero mark opposite one pole of the magnet and the disk is turned until the force of the spring overcomes the attraction of the magnet, when the needle suddenly flies back to the (displaced) zero. The number of the scale division at which the needle stood immediately before the rupture of equilibrium is a measure of the strength of the magnet. This number may be inscribed on the magnet to serve as a standard of reference in comparing it with other magnets and in future tests made for the purpose of determining whether, and to what extent, it has lost magnetism.—*La Nature*.

#### Rolling Stock of Japanese Railways

KOTARO TANAKA, a director and the manager of the Japan Rolling Stock Co. (Mihon Sharyo Kwaisha), in an article on the future of the rolling-stock industry in Japan, contributed to the journal, *Industrial Japan* (*Kogyo no Dainihon*), of May 1st, states that the amount of rolling stock which will be required in the near future as a result of the expansion of Japa-

nese railways will be very large. He says that the estimated amount of new rolling stock to be placed on the government lines in that country between 1910 and 1923 consists of more than 500 locomotives, 750 passenger cars, and 9,300 freight cars, to cost about \$12,450,000. This amount will be needed prior to the completion of the broad gauge line between Tokyo and Shimonoseki, probably to be commenced next year, while almost twice as much will likely be required after its opening, some time around 1925. In addition to this, considerable quantities of rolling stock will be demanded each year by light railways, the construction of which by private companies is encouraged by the government. Seventeen or eighteen companies were organized for this purpose only last year, the total mileage of the lines projected by them being about 230. Mr. Tanaka says that with the enlarged demand for rolling stock domestic manufactures will be stimulated to increase their output. He urges that they should endeavor to prevent the necessity for the further importation of foreign railway supplies.—*Railway and Engineering Review*.

# The Spectroheliograph

The Most Important Instrument in the Study of Solar Physics

By Frank C. Dennett

The most powerful instrument in the hands of the solar physicist is the spectroheliograph. The following description of the instrument is taken from *Knowledge*. The focal image of the sun, formed by an object-glass of very long focus, is made to fall on the slit plate of a spectrograph, the slit of which is greater in length than the diameter of the image falling upon it. As the object-glass has a long focus, that of the collimating lens must be proportionally long. The diagram (Fig. 1) shows the optical contents of the prism box of the Mount Wilson "Rumford" spectroheliograph. *C* is the tube of the collimator; *D* was formerly a plane mirror, but is now replaced by a diffraction grating ruled with twenty thousand lines to the inch; *P P* two light flint glass prisms 60 degree angle. The spectrum, instead of being examined with a telescope, is caused to fall upon the sensitized plate which replaces the eyepiece of the observing telescope. Before reaching the plate, however, it is intercepted by a second slit, which cuts off all the light save that passing through the tiny portion of the spectrum required—say the K line of Calcium, or the C line of Hydrogen. The image of the sun travels slowly across the first slit, and the photographic plate is caused to travel behind the second slit, by clockwork, at a corresponding rate. Two exposures are made when prominences and disk are to be photographed. A slower exposure for the prominences, the disk being hidden by a screen, and a second rapid exposure, when the screen is removed, for the disk. The total deflection of the ray is 180 degrees, the prisms doing the double work of increasing the dispersion, and getting rid of the small amount of scattered light caused by the diffraction plate. Hydrogen prominences and flocculi are best studied in photographs taken in the red light of *C*. The greater the density of the gas or vapor causing a line, the greater also is the width of the line. The closer a vapor is to the sun, the greater is its density also. Hence it is found that by taking photographs with the light of the middle of a line and comparing it with that of the edges of the line a different image is obtained.

The photograph obtained with the center of the line is largely that of the upper clouds, while that with the edge of the line is a picture of the lower, denser masses.

The spectroheliograph here reproduced from our contemporary *Knowledge* was obtained by Professor George E. Hale, at Mount Wilson, on July 17th,

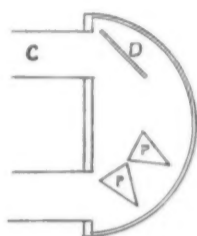


Fig. 1.—Diagram of the Principal Parts of the Spectroheliograph: *C* collimator tube; *D* mirror or diffraction grating; *P P* glass prisms.

1907, in the light of calcium. The prominences around the southern hemisphere are very fine. The tall tree form on the southwestern limb has an altitude of eighty-seven thousand miles. The beautiful double arch southeast extends over a distance of two hundred and thirty-four thousand miles, the taller arch being fifty-five thousand miles high, while the cloudiness over the southern arch reaches over eighty-two thousand miles in height. The great calcium clouds, or flocculi, over the faculae of the great group near the center cover an area over one hundred and thirty-seven thousand miles east to west.

## The Palaeontologist's View of Evolution

IN his studies of evolution Prof. Henry Fairfield Osborn, president of the American Museum of Natural History, has long held out against the strict

Darwinians or selectionists on the one hand, and against the DeVriesians or mutationists on the other. He has laid special stress on the geological evidence of "definite variations" and of the tendency of animals to evolve in some definite direction. The palaeontologist is, he maintains, "practically immortal" as an observer, since his range of observations extends over tremendous stretches of time; whereas the botanist or the zoologist gets but fleeting glimpses of the fundamental processes of transformation. The former gets the impression of continuity and definite tendency of evolution; the latter get the idea of discontinuity, and of direction determined only by selection.

After taking exception to the use of the term "mutation" by DeVries to designate discontinuous variations or "saltations"—since this term was used by Waagen in 1869 to designate the stages in a continuous process of evolution, Osborn admits that recent experiments and discoveries in Mendelian phenomena have greatly strengthened the doctrine of discontinuous evolution. He harmonizes the two extreme attitudes by claiming that the normal process is a continuous one and admitting that under exceptional conditions new characters may arise suddenly.

These reflections arise from his study of the Titanotheres, which furnish the most complete body of material of any extinct family of mammals. Since both biologists and palaeontologists agree that the transformation in the germ is the essential factor in evolution, Osborn leaves out of consideration phenomena resulting from the action of the environment upon the developing organism or from the action of selection upon a succession of organisms. In the animals considered he finds four kinds of changes to have taken place:

1. *Increase of Size.* This is almost universal for this family, although not so for all mammals, nor even for all herbivores.

2. *Loss of Parts.* This principle is more prominent in some other families of mammals.

3. *Changes of Proportions.* This is the most prominent and the most significant principle observed in this group. These changes are designated "Allometric" by Osborn; and new parts originating by this process he calls "Allometrons." Allometrons arise independently of remote ancestral hereditary control. It is not clear from Osborn's description that in this respect the allometrons are anything but discontinuously originating unit characters of the mutationists. But he insists that they are continuous in their origin, as shown by measurements made on long series of specimens.

4. *Rectigradations.* These are adaptive origins of new characters in a definite direction, as exemplified by the cusps on the teeth, or new horns on the skull. In regard to the rectigradations Osborn enunciates four principles:

(a) They appear under the law of an ancestral hereditary control, the same character arising independently at different points in the lines of descent from common ancestors.

(b) They are continuous, arising from minute beginnings and developing to the stage of usefulness. This principle had been previously described by Osborn, especially for the horse family, as "definite variation."

(c) They are subject to the influence of surrounding parts, as the shape of the base of the horn may be influenced by the general proportions of the skull.

(d) They are probably subject to fluctuations.

From these studies, as from earlier studies on the fossils of horses and their ancestors and of other lines of mammals, Osborn is confirmed in his view that the law of continuity, "of orderly and in a sense of predetermined transformation can now be established beyond refutation." His general reconciliation of apparently conflicting views he expresses in the following words:

"The normal development of unit characters is a continuous progress; under certain abnormal conditions, as of sudden change of environment, certain new unit characters may appear suddenly; the cross-breeding of pure natural races in which unit characters have been built up by continuous processes breaks up these unit characters into a mosaic and gives rise to the larger part of the apparently saltatory or discontinuous phenomena which are being observed by the modern experimentalists." He believes that if the experimentalists should confine their operations to pure races they would find only continuous series of characters.

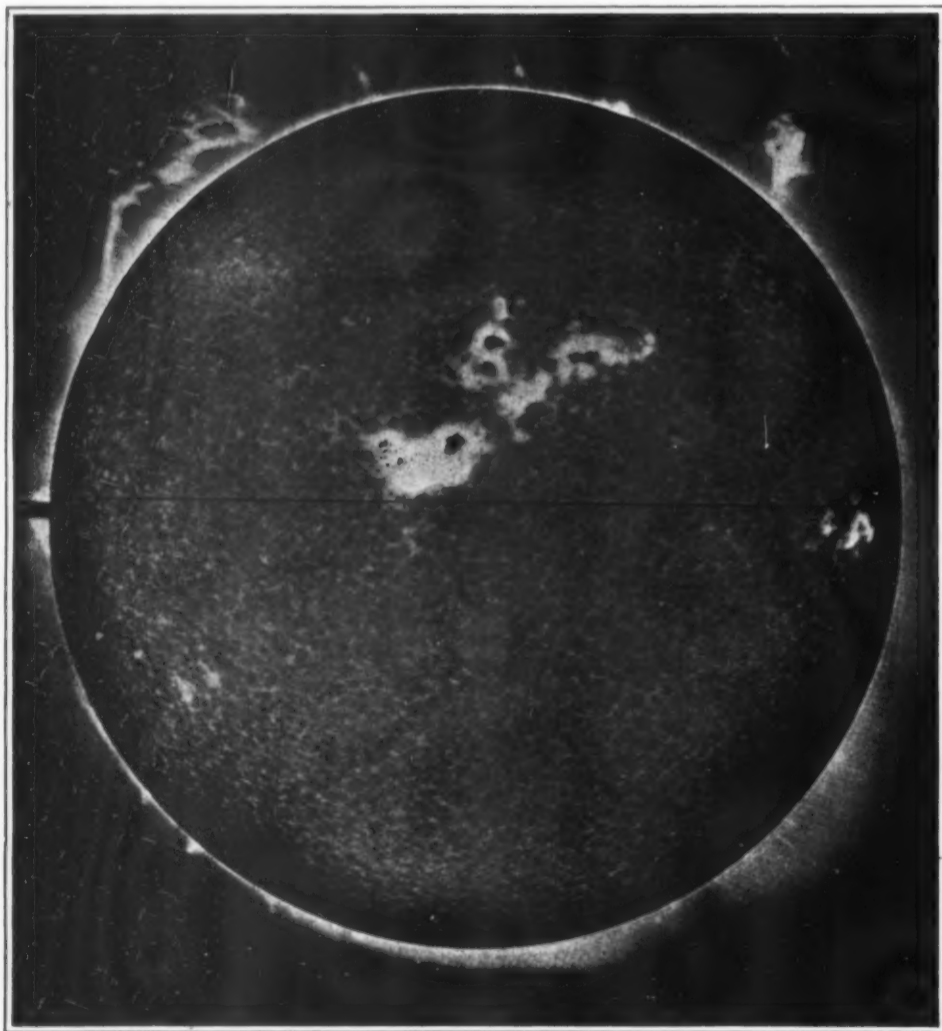


Fig. 2.—Spectroheliogram of the Sun. Photograph Prepared by Prof. G. E. Hale of Mount Wilson Observatory.

# The Lost Eros of Praxiteles

Antique Masterpieces Recovered from the Ocean Bed

FULL details have recently been published of one of the most curious and important archeological discoveries of modern times.

Sponge-fishing is an ancient practice in the Gulf of Syrtes on the northern coast of Africa, and the divers frequently descend to a depth of 130 feet. In June, 1907, one of these men, diving at a distance of three miles from the coast, northeast of the little town of Malidia, came across a strange collection of

by Callistratus of the statue of Eros the Archer by Praxiteles.

The bronze, which is now one of the chief ornaments of the Museum of Bardos, is about 4 feet 7 inches in height. The god, winged and nude, stands with the weight of the body resting on the left foot in an attitude which brings out the curve of the hip. The right leg is slightly bent and the position of the toes shows that the ground on which they rested was uneven.

The right arm is raised and flexed, the hand being raised to the forehead. The left arm is missing, but the slope of the shoulder shows it was lowered and Callistratus tells us it held a bow.

The modeling of the body is very perfectly finished, that of the head somewhat less so. Portions of the wings remain.

MM. Merlin and Poinssot remark that the sculptor has represented the figure in an attitude halfway between repose and action. The wings seem to beat the air, the hair waves in the wind, the face gazes eagerly toward some invisible goal.

There is perfect harmony between the attitude and the physical aspect. The body is that of a youth whose limbs, slender but vigorous, show the training of the athlete. The face, strongly cut, and a trifle willful, shows the eager boy, full of spirit, and glorying in his physical strength.

Second only to this in historic importance and artistic value is a Hermes of Dionysos, i. e., a sort of pillar or boundary stone surmounted by a head of the divinity. The pedestal is hollow and partly filled with lead to give it stability. The head presents an archaic aspect with its hair arranged in stiff cork-screw curls. The face, on the other hand, is noble of expression as in the classic age. This discrepancy would make it difficult to determine to what epoch the statue belongs, but that fortunately the sculptor, Boëthos of Chalcædon, has inscribed his name upon it. Boëthos lived in the second century B. C., and was highly valued by the ancients, Pliny in particular praising him in the highest terms. Many writers have described his principal works, of which one has been often copied and contributed much to his reputation. This is the well-known "Boy with the Goose," an antique copy of which in marble is to be found in the Louvre. The Dionysos just discovered is, however, the only one of his original works which has descended to us.

Among other artistic treasures found are two bronze cornices of much elegance, representing Ariadne and Dionysos.

A fine bust of Athena also deserves special mention. The goddess wears a tunic, which leaves the neck partly exposed, and bears the Gorgonis head shield. On her head is a casque of striking design from which three gracefully floating streamers fall to the shoulders. This bust, which measures only seven inches in height, must have been used as an applique or ornament for some article of furniture, as was also a similar one of Artemis carrying a quiver on his shoulder. Many other appliques were found representing various subjects and numerous fragments of the beds, chairs, etc., which they adorned, were also discovered, so that it is hoped that examples of the furniture of the period can be restored.

These articles recall those found at Pompeii. Among the interesting bronzes are two statuettes, somewhat damaged, which represent the personages of a lampadrome, i. e., one of those torch races which were so frequent a feature at ancient fetes. The two figures differ somewhat. In one the runner is shown in full course, in the other the artist has seized the moment when the lampadephoros pauses to pass his torch to another runner. These bronzes were used as lamps, the head and top of the body joining a reservoir for the oil which ran into the extended arm and torch to feed the wick.

The marbles are fewer and of less value than the bronzes. They comprise fragments of statues larger than life-heads of fauns and satyrs, torsos of men, etc., and also statuettes, dancing cupid, etc., all rather mediocre.

One charming head of Aphrodite deserves mention, however, for its somewhat pensive sweetness. The shoulders are much corroded by the action of marine animals.

The careful examination of numerous fragments of white marble evidently belonging to two or three large vases led to the discovery that one of these was an exact replica of the Borghesè vase now in the Louvre, and another is a copy of one in the Campo Santo of Pisa. Both are ornamented with Bacchic scenes.

Two hypotheses to account for the presence of these objects of art in the sea presented themselves—that of a submerged city and that of a shipwrecked vessel. The former seemed at first the more plausible because of a number of marble columns besides such things as slabs of marble, tiles, pieces of pipe, bolts and rivets of bronze, etc., which were found, together with the statues.

But further investigation proved that the theory



Bust of Hermes, Forming the Headpiece of a Pillar. The Work of Boëthos of Chalcædon.

bronze and marble objects half buried in the ooze of the ocean bed. Some of these having been offered for sale to the Museum of Antiquities of Tunis, this led to a methodical investigation under the auspices of the French and Tunisian governments together with the Academy of Belle-Lettres and Inscriptions. The work was directed by M. Alfred Merlin, head of the museum, assisted by M. Poinssot, and was carried on in the summers of 1908, 1909 and 1910.

One of the most recent finds in this remarkable treasure trove is an exquisitely beautiful statue of Eros which has been proved beyond a doubt to be, if not the original, at any rate a faithful replica, of the famous lost Eros modeled by the mighty hand of Praxiteles. Though broken into many fragments and buried beneath a marble column when found, it has been very carefully reconstructed and tallies exactly—even minutely—with the detailed description given



Marble Bust of Aphrodite.

of a wreck offered the true solution. In the first place only one group of columns was found, and these, which are sixty in number and not fluted, are disposed in regular order with their Ionic capitals all at one end. Secondly, the limited area of the deposit and the discovery of five leaden anchors at one end confirms the conviction that these were treasures meant for some public building or magnificent private house in Rome and were lost in transit by the wreck of the bark conveying them.

Since the vessel was of the modest dimensions of 100 feet in length by some 25 feet beam, and its contents are computed to have weighed 400 tons, its wreckage is not surprising. One of the anchors was raised with immense difficulty and found to weigh 1,500 pounds. It is of a type familiar through many discoveries in France, Spain, and Cyrenaica.

Among the articles on board were a large number of utensils for daily needs, such as amphoræ and jars for water, wine, oil and food. In one of these a quantity of peas was found.



Grotesque Figure.



Bronze Eros of Praxiteles.



Eros Playing the Lyre—A Very Fine Bronze.

But most precious of all such household conveniences is the lamp, dating from the second century B. C. and obviously in actual use at the time, since it still contains a bit of charred wick.

*La Vie Illustrée* relates a curious incident in this connection. When M. Merlin presented his monograph before the Academy of Belle-Lettres and Inscriptions a venerable member arose and with trembling voice inquired whether the wick was of cotton. For 50 years he said, he had been trying to find out whether the ancients used cotton wicks but had failed for lack of evidence. This point will doubtless be settled by the microscope.

In conclusion M. Merlin hazards the conjecture that these treasures meant to adorn Imperial Rome had been collected by the celebrated ruler, Juba II, of Mauretania.

### The Plague in Manchuria

No VERBAL description can give so vivid and gruesome an impression of the recent plague in Manchuria, which is now happily conquered, as is conveyed by the photographs of funeral pyres, with the charred bones of hundreds of men and horses protruding from their ashes, of victims stricken by the wayside and hastily borne to the pest house to die and of other ghastly scenes of death and suffering. A few of the

into the eternal sleep of death. The comprehensive statistics collected by the German Surgical Society give one death for each 2,975 inhalations of chloroform and one death for each 5,112 inhalations of ether. It is not surprising, therefore, that surgeons have sought methods of avoiding the dangers of narcosis without depriving their patients of the benefits of anaesthesia. The first object sought was to substitute local for general anaesthesia. This was first accomplished by freezing the skin by means of a spray of ether or ethyl chloride. This method suffices only for small and superficial operations, such as the lancing of boils, and it has the disadvantage of producing severe pain while the frozen flesh is thawing. The introduction of the new anaesthetic cocaine into oculists' practice was of great benefit to general surgery. The infiltration method of producing local anaesthesia with the aid of cocaine was developed by Reclus and Schleich. In this method a solution of cocaine is injected into the skin and the subcutaneous tissue, which is thus greatly inflated and swollen. Operations can be performed without pain in this infiltrated tissue. The very poisonous character of cocaine and the difficulty, especially the operations on tumors, of distinguishing the diseased and normal parts of the swollen tissue led Oberst, Hackenbruch, and notably H. Braun, to modify the process in various ways: by changes in the methods of application, by the substi-

"The name of A. Bier is also connected with another method in which the entire lower half of the body is made insensible by interrupting communication through the nerve trunks which connect it with the brain. This object is accomplished by injecting solutions of cocaine or its substitutes into the spinal cord. The solution bathes the roots of the sensory nerves and paralyzes them. The effect is wonderful. The most extensive operations can be performed in all parts below the navel without producing the slightest sensation.

Unfortunately, however, the method has many serious disadvantages. In many cases its application is followed by very severe headaches, which continue for days, and it has proven so dangerous that its application is now confined by most surgeons to cases in which general anaesthesia is inadmissible and strictly local anaesthesia is insufficient or impracticable. Possibly the process, which possesses many great advantages, may yet be improved and its field of application enlarged.

"In the last decade, also, the methods of producing general anaesthesia have been greatly improved. Schnelderlin and Korff have shown that by repeated injections of small quantities of scopolamine and morphine beneath the skin it is possible to produce, in about ninety minutes, general anaesthesia of sufficient intensity to enable operations to be performed without pain. If this method were entirely free from danger it would constitute a great advance, as it dispenses with the attendance of a skilled assistant; but, in its original form, it is far more dangerous than the employment of ether or chloroform. The injection of scopolamine and morphine, in very small doses, however, forms a very useful preparation for the production of anaesthesia by inhalation of ether or chloroform.

The patient treated with morphine and scopolamine comes to the operating table in a calm, drowsy condition, requires comparatively small quantities of ether or chloroform to produce complete anaesthesia and sleeps after the operation for hours and until the first severe pain of his wound has passed away.

"Attempts to introduce ether or chloroform, dissolved in a saline solution, directly into the blood, were made last year by Burkhardt, but have not yet led to any satisfactory results, as the method involves the danger of carrying blood clots into the lungs. No better success has been obtained from recent repetitions of the old attempts to produce anaesthesia by the introduction of ether vapor into the rectum, a method which would be very useful in operations on the face, head and neck.

"Recent efforts to diminish the dangers of ether and chloroform anaesthesia by improvements in method have been more successful. It was formerly the practice to pour the anaesthetic in large quantities upon the mask, and to apply ether to the mouth and nose by means of masks which completely excluded the air. In this way the production of anaesthesia was produced more quickly, but the patient was tortured by the fear of suffocation. Furthermore, the great concentration of the chloroform and ether vapors with which the organism was overwhelmed was attended by serious danger. Sudden deaths by stoppage of the heart in the first stage of chloroform narcosis, and the production of fatal inflammation of the lungs by ether, were due chiefly to these incorrect methods of application. These dangers are now avoided by dropping the anaesthetic upon a porous mask which allows free entrance of air. The vapors are thus mixed with air before inhalation, and anaesthesia is produced less rapidly, but the danger to the heart and lungs is greatly diminished. By means of special forms of apparatus, which, on account of their great cost, weight and size are suitable only for hospital use, the vapor of chloroform or ether can be mixed in any desired proportion with oxygen, which, when inhaled, exerts a very stimulating action upon the whole organism. The use of chloroform and ether in combination or in alternation has also proved useful, especially if the patient is first brought into a half sleep by means of narcotics by the methods described above.

"The quantity of the anaesthetic can also be reduced by Klapp's method of diminishing the quantity of blood to be saturated with it. This is accomplished by applying tight elastic bandages to the arms and legs, or to the legs alone. The blood in the members thus isolated remains free from chloroform or ether and the quantity of blood in circulation is considerably diminished, so that a comparatively small quantity of the anaesthetic saturates it sufficiently to produce the required benumbing effect upon the brain. At the close of the operation, or in any emergency, the bandages are loosened, and the pure blood flows back from the arms and legs, mixes with the general circulation and immediately diminishes the relative proportion of chloroform or ether so greatly that the danger of an overdose can be promptly averted.

"Finally, we may note that Sudeck has recalled at-



Reception Room in a Pest House.



Disinfecting a Physician.



Corpse Bearers.

### PLAGUE SCENES IN MANCHURIA.

more interesting and less horrible of these photographs are here reproduced from *Die Umschau*. The physicians, nurses and attendants who risked their lives in the service of humanity during the plague are deserving of the highest praise and admiration. The fact that few of these heroes died is due to the extraordinary and minute precautions against contagion which they observed. All wore gloves and loose coats and trousers which could be washed. The mouth and nose were protected by veils and even the hair was covered. On leaving the hospital every physician and attendant was immediately sprayed with disinfectants, by a man stationed outside. In this and other ways the dreadful scourge has possibly produced one good result—the inculcation of an idea of the importance of cleanliness and sanitation in the minds of the filthy natives.

### Modern Methods of Anaesthesia in Surgery

The two well-known anaesthetics—ether and chloroform—have done much for the development of operative surgery since their introduction in 1846 and 1847. Only under the protection of anaesthesia, which affords the operator opportunity for calm and uninterrupted work, is it possible to employ the very intricate and slow methods of operation which are now used hundreds of times daily for the relief of human suffering. These anaesthetics are poisonous, and have the power to paralyze the heart and the organs of respiration, as well as the centers of sensation and consciousness. Their use, therefore, involves the danger that the beneficent sleep of unconsciousness may pass

tution for cocaine of less poisonous agents, and by the addition of extracts of the adrenal glands to the anaesthetic solution. The direct infiltration of the tissue was replaced by injecting the solution in a circle surrounding the field of operation, or in operations on the fingers and toes, by injecting at the base of the member around the four principal nerve trunks, and thus interrupting the communication of sensation to the brain. The addition of minute quantities of extract of the adrenal glands increases the anaesthetic effect so greatly that the volume and strength of the poisonous solution can be very much diminished, and also prolongs the effect so that no pain is felt for hours after the operation. The astringent action of the adrenalin extract, furthermore, makes the operation almost bloodless. Finally, A. Bier discovered that by the injection of such solutions directly into a blood vessel in a member which had previously been made bloodless by a certain method, the whole member could be made so insensible that the most extensive operations, including amputation, and cutting and sawing bones, could be performed without pain.

"By these improvements," says Dr. Richard von Hippel, in *Die Umschau*, "the method of local anaesthesia has gradually extended its field of operation. This field is, however, necessarily limited. The patient remains conscious, so that his mental power of endurance is always to be reckoned with and, for reasons of operative technique, the method must be confined to typical operations, the course of which can be clearly foreseen. Within its own field of operation, however, this method is preferable to all others, because of its entire freedom from danger.

tention to a valuable property of anaesthetics, especially ether. At the beginning of the inhalation of ether, long before consciousness is lost, there is a transient stage of complete painlessness, which lasts long enough for the performance of brief operations. In this stage the patient usually has pleasant dreams,

laughs, and talks incoherently. After the removal of the mask, he promptly awakens, is often conscious of what has been done, but says that he has felt no pain. This ether intoxication, which is absolutely free from danger, is now used very extensively in connection with local anaesthesia.

"We see, then, that although the production of anaesthesia is even yet not entirely free from danger in all cases, we have at our disposal a number of methods which, when carefully selected and applied, will reduce the danger to a minimum and will often eliminate it entirely."

## Radium in Biology and Medicine

### Its Effect on the Normal and the Diseased Organism

By Dr. E. S. London

THE first study of the action of radium rays on protoplasm was made by Schwartz, who exposed a hen's egg during 144 hours to the radiations from 20 milligrams of radium. The shell of the egg was blackened and the white became turbid and less fluid, but the most marked effect was produced in the yolk, which also became less fluid, assumed a yellowish green tint and emitted the odor of trimethylamine. Schwartz attributed these changes to the decomposition of lecithin by the action of the rays and ascribed the physiological effects of radium to such decomposition. This view was confirmed by other observers, but Meserwitzki found that lecithin is similarly affected by heat, acids and alkalis, and he consequently denied the existence of any strictly specific influence of radium. He found, however, that injections of radioactive lecithin into living tissues produced the same changes that were caused by direct radiation. Apart from the practical interest of these observations, they suggest an explanation of the physiological effects of radium by the action of the decomposition products of lecithin, cholin, trimethylamine, phosphoric acid, etc. Injections of cholin have been found to produce effects similar to those of radium radiation. Those organs which are richest in lecithin appear the most sensitive to radium, but the proportions of lecithin in various organs and tissues are not yet thoroughly known. On gelatine, according to Rudge, radium exerts no effect. A thorough investigation of the action of radium on fats, carbohydrates, and salts is greatly needed. Orlov has observed decomposition of paraffine, fatty acids, etc., under the influence of radium.

Poehl and Larchanow, who have exposed cerebrin, ovarin, venin and other extracts of animal organs to radium rays, suggest that the changes observed may have been caused by a generation of ozone, as well as by decomposition of lecithin.

Other observers attribute the effects of radium to a general disturbance of the chemical and mechanical processes of the cells, to the stimulation of ferments, etc.

**Action on Bacteria.**—The power of radium rays to arrest the development and the life of bacteria, both in laboratory cultures and in the living body, has been proved by many experimenters. The bactericidal effect is due, not to changes produced in the culture medium or the air, but to a direct action of the rays on the bacteria. Among the bacteria thus affected are the germs of typhoid, cholera and splenic fever. Hoffmann found that bacteria resisted the action of radium far better in liquid than in solid media, and that no appreciable effect was produced on a bouillon culture of anthrax germs by five days' exposure to the radiation of 12 milligrams of radium.

Goldberg, working in London's laboratory with larger quantities of radium, proved that the bactericidal effect increases with the amount of radium and that the three kinds of rays act in proportion to the readiness with which they are absorbed, the  $\alpha$  rays being the most effective and the very penetrating  $\gamma$  rays the least effective. The experiments were made by placing from 5 to 75 milligrams of radium salt beneath a flat glass dish containing a culture of bacteria in agar and measuring the diameters of the sterile spots produced in from 5 to 8 hours.

The bactericidal action of radium emanation has been proved by Lanyse and also by Goldberg. In Goldberg's experiments a tube coated internally with a thin stratum of bacteria-infected agar was connected by a bent tube with a flask containing a solution of 10 milligrams of radium bromide, from which radium emanation flowed continuously into the culture tube. The tube inoculated with typhoid remained sterile three days, and the anthrax tube six days, although colonies of bacteria developed rapidly in control tubes, not exposed to the emanation. At least 8 hours' action was required to destroy anthrax germs. Other observers have confirmed the bactericidal action of radium emanation, but have found that the effect is confined to a superficial stratum of the medium, not more than 1/12 inch thick.

Bouchard and Balthazard find that radium emanation affects the chromogenic function of the pigment-

forming bacteria more powerfully than it affects their virulence and other properties. Only pigments permanently connected with the bacteria, as in the case of *Micrococcus prodigiosus*, "the bleeding host" bacillus, are destroyed by the emanation, while pigments which diffuse in the liquid medium are little affected. When the bacteria are not killed their chromogenic function returns after a few transplantations.

Most striking is the effect of radium on luminous bacteria. London and Omeliansky found that the non-luminous circle caused by the rays from a small mass of radium salt was separated from the general luminous surface of the agar by a ring of unusual brightness. The cause of this stimulating action is not known.

**Lower Fungi.**—Dauphin, who has examined the action of radium rays on *Mortierella*, *Mucor* and some other lower fungi, finds that the rays paralyze the growth of the mycelium of *Mortierella*, develop protective cysts, and prevent the formation of spores, but kill neither the mycelium nor the spores, so that the normal properties of the fungus can be restored by transplantation to a new medium.

**Ferments, Toxins and Antitoxins.**—The experiments of London and others prove that radium acts in various ways on various ferments and similar bodies, paralyzing some, leaving others unaffected and stimulating still others. Chymosin, invertin, emulsion, snake venom, hemolysin and typhoid agglutinin belong to the first class, pepsin, rennet, trypsin, mallein and diphtheria toxin to the second; and trypsin (according to Danysz) to the third.

Radium rays neither retard nor accelerate the coagulation of milk or blood, or the digestion of albumen by trypsin. Some observers found that the rays destroyed or diminished the virulence of rabies poison, both in the dried spinal cord of rabbits which had died of rabies and in rabbits inoculated with an emulsion of the dried cord, but Danysz found the rays ineffective when applied to an emulsion of fresh spinal cord.

**Plants and Low Animal Organisms.**—Matout found that the germination of mustard and cress seeds was prevented by twenty-four hours' exposure to radium rays. Goldberg, by applying the rays to sprouting beans, diminished the growth in the first week from 4 or 6 inches to 1/10 or 1/20 inch. Injurious effects of radium rays on the respiration and assimilation of older plants have also been observed.

Amoebæ are killed by twenty-four hours' radiation and paralyzed by shorter exposure. *Trypanozoma Brucei* is killed by four hours exposure, according to some observers, while others assert that it is little affected by radium rays. Different species of lower animals, as of bacteria, appear to react to the rays in different ways. London and Goldberg paralyzed, by four hours' radiation, guinea pig spermatozoa suspended in a serum in which they normally remained active several days, and Seldin destroyed most of the spermatozoa in the living animal by a few brief applications of the rays.

**Embryonal Development.**—Experiments with hens' eggs and eggs and embryos of frogs and other animals show that radium rays can arrest development and cause abnormal growth. In unfertilized eggs the rays produce changes suggesting parthenogenesis, but the segmentation is irregular and soon ceases.

Burke and Dubois claimed to have produced living organisms by exposing sterilized gelatine to radium rays, but the supposed organisms are regarded by other observers as crystals, or as air bubbles coated with a fine precipitate.

**Organs and Tissues.**—The power of radium rays to cause inflammation and ulceration of the skin, first discovered by accident, has been abundantly confirmed by experiments on men and animals. A period of incubation, varying from a few days to several weeks, according to the intensity of the rays and the time of exposure, has been noted by all observers. The skin is astonishingly sensitive to the rays. Curie found that ten minutes' exposure to rays that had traversed thick glass caused slight inflammation twenty days afterward, and London produced lasting

dark red discoloration by applying a pill box containing 18 milligrams of radium to the arm for fifteen seconds. The aggregate mass of the radiant particles that struck the skin in this interval was about one two-million-millionth of a gramme!

In mice, radium applied to the brain produced convulsions and partial paralysis. Symptoms of congestion, and, in some cases, of hemorrhage, were found in the brain. The effects produced by radium on the peripheral nervous system have been little studied, although radium has been found to allay pain in neuralgia, cystitis, gout, and other diseases.

The effect of radium on the eye has been studied by London and others. The application of radium to the head produces a sensation of light in closed eyes, even those of blind persons who have not lost all sensitiveness to light.

By utilizing the power of radium to produce bright lines and figures, and also, with a special arrangement of apparatus, sharp shadows, on a fluorescent screen, London has enabled blind persons with incomplete atrophy of the retina to read and write. The same result can be obtained, with more difficulty, by the use of ordinary light. The sensation of light caused by radium rays entering the eye is due to fluorescence excited in the refractive media, and possibly in the retina, and also, perhaps, to direct stimulation of the visual center in the brain. The rays produce no observable change in the retina of a freshly killed animal.

From a review of the observed action of radium rays on various organs, London draws the following conclusions: Every organ is affected in a specific manner by long-continued exposure. The lymphoid organs, such as the spleen and bone marrow, are most sensitive, and suffer destruction of the lymph cells. Radium rays destroy spermatozoa in the testicles and produce atrophy of the Graafian follicles in the ovaries. Inflammation and atrophy are produced in various elements of the brain and spinal cord, necrosis of active cells and growth of connective tissue in the liver. In the kidneys intense radium rays cause necrosis, but weak rays merely produce great congestion. Muscular tissue is disintegrated, while the growth of cartilage is sometimes promoted. Degenerative changes are produced in the walls of the blood vessels. In general, stimulation is produced by small doses of radiation, necrosis and atrophy by large doses. Well-founded and concordant data exist, however, only for the skin, testicles and lymphoid organs.

**General Effects on Higher Animals.**—In 1903 Danysz found that tubes containing radium, inserted beneath the skin of young animals, near the brain or spinal cord, produced symptoms of paralysis and ataxia in three hours, and tetanic convulsions in six hours. London produced coma and partial paralysis in mice by four days' exposure to radium rays. In May, 1904, London placed three rabbits in a small cage with a radium capsule. No effect was observed during the first fortnight. Local and general disturbances then appeared, and increased in severity until the rabbits died, in June, July and August of the following year. Inflammation, ulceration and loss of hair, beginning with the ears, extended to the back, which finally became completely denuded. The animals began to grow sluggish and listless within a month. In eight months disturbances appeared, and at last the hind legs became paralyzed and the rabbits dragged themselves along on their bellies with their forelegs. The retina and optic nerve were affected and toward the end the eyes were usually closed and covered with a thick secretion. The female rabbit gave birth to three litters during the first year, after which the sexual impulse weakened, and finally vanished. The weight of the animals increased until December, and then diminished.

London confined frogs in bottles which contained a little water and were connected, permanently or intermittently, with vessels in which radium emanation was generated. The morbid symptoms, which began to appear on the sixth or seventh day, included sluggishness, sleepiness, sliminess of the skin and difficulty in respiration, which caused death in about a

fortnight. The frogs were found to be strongly radioactive throughout the experiment, and even after death. Examination of the bodies revealed abnormal softness of the skin and dark color of the blood, scaling of the horny cuticle of the back, congestion of the dermal blood vessels, and degeneration of the glands and connective tissue of the skin.

Similar experiments, except that no water was put into the vessels, and the application of the emanation continued only a few hours, were made with suckling mice. No injurious effects were observed until the third day afterward, when the mice succumbed to asphyxia.

**Therapeutic Applications.**—Radioactive substances have been employed in the treatment of a number of diseases, and various methods of application have been devised.

Externally, the salts of radium, in greater or less purity, are employed to produce action at a distance, and are also applied directly to the surface and cavities of the body in the forms of powder and ointment and by means of compresses and tampons. Strebel devised the following method of treating cancers with radium emanation. Charcoal is heated to incandescence in a closed vessel, which is then evacuated with an air pump and connected with a small vessel containing radium salt which is heated. In these conditions the emanation is very rapidly evolved and absorbed by the charcoal, which becomes strongly radioactive. The charcoal is strewn on cancerous surfaces or injected in the form of a glycerine suspension.

Baths containing radium salts in solution act in part externally and in part by the entrance of radium emanation into the lungs.

Internally, radium emanation is administered by inhalation, and water impregnated with emanation is given by the mouth and by injection into the tissues. Emanation administered by the mouth is absorbed in the digestive tract, and appears to be eliminated chiefly through the lungs and bowels, little or none appearing in the urine, according to most observers.

The good results obtained by Building and Sommer from inhalations of radium emanation in diseases of the respiratory tract have caused this method to be adopted extensively. In Building's inhalation apparatus the emanation is purified by water vapor and is inhaled in a moist state, while Sommer's apparatus is so contrived that the emanation is introduced into the lungs in a perfectly dry condition. Loewenthal constructed an "emanatorium," in which several persons can receive the inhalation treatment for a number of hours.

In 1905 Braunstein asserted that the internal parts of tumors could be affected by injections of water containing radium emanation. Aschoff impregnated brine with emanation by bringing it into contact with insoluble radioactive substances and injected this radioactive brine in doses increasing from 1 to 50 cubic centimeters.

Diseases of the skin may be treated by direct application of radium salts, contained in an ebonite capsule, with a window of mica, which absorbs little of the radiation. The mica window is placed in contact with the diseased skin, and the surrounding parts are protected by wrapping the capsule with lead foil. Some experimenters have sought to obtain deep penetration without excessive superficial action by long continued treatment with a capsule wrapped in sheet rubber. Butcher claims that radium acts best when it is sealed in a very thin platinum capsule. Other experimenters have employed radium salts strewn thinly on metal plates and covered with aluminum foil, mica, celluloid, or simply with varnish.

According to Wichmann, two-thirds of the radiation is absorbed by the skin and the rays are absorbed far more by diseased than by healthy tissues. Horand found that the pigment in negroes' skins opposes a serious obstacle to the radiation.

**Cures Effected by Radium.**—In 1903 Goldberg and London treated two cases of ulcer (*ulcus rodens*) with radium rays. In the first case the treatment was continued two and a half months, in which the actual exposure to the radiation aggregated seven hours. The ulcer was apparently healed and was replaced by a cicatrix and new skin, but the subsequent history of the case is not known. In the second case the cure effected by three months' treatment and four and a half hours' exposure proved only temporary. A second treatment was followed by improvement which continued for eighteen months. The disease has since been held in check by repeated brief treatments.

In 1903, also, Exner cured a cancerous growth on the lip by six radiations, each continued 15 minutes, and a sarcoma by a few radiations of from four to twenty-five minutes. Microscopic examination showed the gradual replacement of the cancer cells by new connective tissue. This change became perceptible in a week, and was completed in two months. In the same year Holzknecht cured a case of epithelioma of the cheek, and the American physician Cleaves re-

ported striking improvement in sarcoma of the face.

In the following year many more successes were reported. Exner treated three cases of cancer of the esophagus by introducing a bulb containing 60 milligrams of radium, and thus effected considerable enlargement of the passage. Goldberg, Helnitz, London and others have treated many cases of *ulcus rodens*, with entire or partial success, and analogous results have been obtained from the application of radium to various forms of cancer. Manby cured a cancer of the breast by forty treatments, each of twenty minutes' duration, with the rays emitted by 20 milligrams of radium. Morestin recommends the employment of radium to complete the cure of sarcoma, after operation. Strebel has cured many canceroids on the eyelids by the radium treatment.

The microscopic changes produced by radium rays in human cancerous tissue have been studied in London's laboratory in St. Petersburg. The introduction of a tube containing 1 milligram of radium effected in six days a complete disappearance of cancerous cells through a layer one-eighth to one-fifth inch thick around the tube, and a great accumulation of leucocytes, with distension of the capillaries, hyperemia and formation of connective tissue.

Radium has been employed by numerous experimenters in the treatment of granular growths, as in trachoma. Cohn applied a glass tube, containing 1 milligram of radium bromide, directly to the granulation for a few minutes daily, and obtained rapid and painless cures in three cases of trachoma. Many other cures of trachoma have been reported.

Lupus is another disease in which radium has been employed very successfully, and it has also been found very effective in the treatment of moles, warts, eczema and psoriasis. In local infections, as in wounds, however, radium is of little value.

Many observers have noted and utilized the power of radium rays to allay pain.

The waters of many springs contain radium emanation and ordinary water can be made radioactive by treatment with uranium residues and in other ways. Baths of such natural and artificial emanation-water have been found beneficial in rheumatism, gout, neuralgia and various catarrhal diseases, and it appears highly probable that radium emanation is the most important constituent of many famous remedial waters. As the emanation is a gas and the skin is almost impenetrable to gases, the effects are chiefly due to the inhalation of the emanation which rises from the bath.

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#### Progress in Unwatering the Maine Cofferdam

By ALBERT DIAMANT, Havana, Cuba.

THE construction of the "Maine" cofferdam, described in the *Engineering Record* of October 22nd 1910, and May 20th, 1911, was completed at the beginning of June. Careful inspection on the part of the army engineers in charge of the work, having satisfied them that everything was in readiness for a preliminary unwatering, preparations were made to commence the pumping. On June 6th, 4½ feet of water were pumped out, and the day following an additional 1 foot was taken out. On June 15th, the day after the arrival of Brig. Gen. W. H. Bixby, chief of engineers, Col. William M. Black and Lieut.-Col. M. M. Patrick, 5 feet more were pumped out, bringing the gage reading to 10½ feet. On June 19th additional pumping brought the level down to 15 feet.

As the pumping progresses weep holes are bored into each cylinder to allow the water to drain off and thus insure a hard, impervious clay. These weep holes drain off all of the water that is accumulated by the daily rains and also the little amount that seeps through the piling. Again some of the piling has been driven low to allow the construction of sluice gates, and where these gates have not yet been put in place the temporary packing allows the water to seep through. But, taken all in all, the amount of foreign water getting into the cofferdam is very small, and, as far as the work is concerned, is practically negligible. No serious leaks of any kind have developed to date.

To provide for refilling the dam 5 x 7 foot sluice gates are being constructed in sufficient numbers for immediate installation. One of these sluiceways is now complete and the other in course of construction. Should the cofferdam show any signs of weakening or should a cyclone put in an appearance water can be admitted in sufficient quantities to avert any disaster.

One 12-inch and one 8-inch suction pump, made by the Jeansville Iron Works Company, of Hazleton, Pa., are used for pumping dry the cofferdam. Both are on floats inside the inclosure. The former can lower the water level in the cofferdam at the rate of one foot per hour and the latter one foot per 5 hours.

As a matter of precaution and to further insure the stability of the cofferdam, the clay in the cylinders is moved from the inner edge toward the outer. This does not remove any material from the cylinders, but by shifting the center of gravity of the puddle out from the center of the cylinder the resultant of the horizontal thrust of the water and of the weight of the puddle is brought nearer to the center of the middle third at the base of the cylinder. This work of redistributing the load to conform to the redistribution of the outside forces is going on now. In addition to this the space between the cylinders, inside the cofferdam, is filled with a clay embankment, and ultimately the slope of this embankment and the slope of the clay in the cylinders are to be approximately the same and the top practically continuous. The object of this added clay is to provide, partly, a pressure to take the place of the pumped water, and partly to counteract the force tending to overturn the cylinders. The toe of this embankment will reach almost to the keel of the ship.

The wreck is full of dirt, reaching as high as 4 feet above the main deck, in what used to be the officers' quarters. Most of this is removed with an hydraulic jet. There still remains about 15 feet of water to be pumped out and then about 15 feet more of harbor mud ere the keel of the ship is reached. This mud has the consistency of very soft butter and may be handled either with a suction dredge, clam shell derrick, or both, as the occasion may call for.

Nothing can be said at present about the method to be adopted in floating the wreck. The question now is whether the wreck can be floated at all. All of the steel is badly corroded. Where the immersed steel was in contact with or close to copper or composition metal the steel has been eaten away; copper and composition metal are in good condition. The wood seems to be fairly well preserved, except where eaten by the ship worm, and no effect seems to have been made on rubber. Gaskets are in good condition and rubber bands are as elastic as new ones. However conditions were found worst near the surface and it is merely conjectural to assume the condition of the wreck further down toward the bottom of the harbor.

General Bixby is highly satisfied with every feature of the engineering work and, though thoroughly prepared, expects no trouble except such as is customary and natural in cofferdam work. The work of unwatering the wreck will go on slowly, to allow ample time for observing the behavior of the cylinders and to allow the cylinders to adjust themselves to the new stresses. Capt. H. B. Ferguson has been in immediate charge of operations since the work was started in the fall of last year.

#### Turbine Locomotive

A SMALL turbine locomotive fitted with especially designed turbines has been successfully tried at Milan. The peculiar feature of the turbine is the use of movable blades, which are operated in series. Four sets of such blades are used, and at high speed the steam strikes the first set of blades only, while at intermediate speeds two sets or three sets can come into play. The reversing mechanism is a special and unique feature of this motor. The rotors have two sets of blades which are of opposite curvature. When running in one direction the steam passes over the blades at the outer circumference from left to right; when running in the opposite direction steam passes over the other set of blades from right to left. In either case the loss of energy due to the blowing action of the second set of blades only amounts to a small fraction of the total, and the experiments show it to be 2 to 3 per cent. It is reported that this engine starts well under load both on curves and gradients, and that the consumption of steam has not exceeded 35 pounds per horse-power hour when running in either direction.

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